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The Public Lighting Tables of the American Meter Company will be found in the page advertisement of that Company.

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[OFFICIAL NOTICE.]

Twenty-Sixth Annual Meeting, Western Gas Association.

OFFICE OF THE SECRETARY,
NEW ALBANY, IND., April 7th, 1903.

The annual meeting of the Western Gas Association will be held at the Claypool Hotel, Indianapolis, Ind., May 20, 21, 22, 1903, and will be called to order by its President, Mr. A. H. Barret, of Louisville, Ky., at 10 A.M., Tuesday, May 20.

Announcements as to rates will be made after the opening of the Claypool Hotel, which is entirely new, and has been in the course of construction for 2 years, which will occur between the 15th and 25th of April. Indianapolis is one of the best hotel towns in the country, and within a few blocks of the Claypool Hotel are a number of hotels conducted on the European and American plan, at which rates suitable to all persons can be secured.

The sessions of the Association will be held in a room provided by the Claypool Hotel.

The Executive Committee has arranged for the following papers:

Naphthaline, by Dr. W. H. Birchmore, Brooklyn, N. Y.

Gas and Meters, by Mr. John McIlhenny, Philadelphia, Pa.

The Most Economical Yield per Pound of Coal, by Mr. James Somerville, Indianapolis, Ind.

Increasing the Sale of Gas to Existing Customers, by Mr. B. W. Perkins, South Bend, Ind.

Municipal Ownership, by Mr. A. E. Boardman, New York City.

High Pressure Gas Mains Under the Mississippi River at New Orleans, by Mr. Thos. D. Miller, New Orleans, La.

Low Candle Power Gas, by Capt. W. H. White, New York City.

Wrinkle Department, Edited by Mr. W. E. Steinwedell, Cleveland, O.

Reports will be made by the following committees: On Specifications for Gasholders; World's Fair Committee.

Arrangements are being made with the various Passenger Associations to secure the usual 1½ rate for persons attending the convention, full details of which will be given shortly.

The Secretary will be pleased to answer any questions relating to the meeting, and will mail application blanks for membership to applicants. The membership fee is $10, which includes the first year's dues, annual dues $5 thereafter. The Association publishes and distributes, free of charge, to its members the Proceedings of the Association, which alone is worth more than the annual dues.

Yours truly,
JAS. W. DUNBAR, Sec'y.

[OFFICIAL NOTICE.]

Wrinkle Department, Western Gas Association.

WESTERN GAS ASSOCIATION,
OFFICE OF THE WRINKLE DEPARTMENT,
721 Citizens Building, Cleveland, O.

To the Members of the Western Gas Association: The Wrinkle Department is now ready to receive contributions for the 1903 collection, and I would thank you to please send a sketch or description of any new device or method you may have to the above address.

APR 13 1903
SMITHSONIAN DEPOSIT.

Any sketch, photograph or drawing, accompanied by a written explanation, of a new idea will be gratefully received, and it is hoped that you will comply promptly by favoring us with a contribution.

Respectfully, W. E. STEINWEDELL,
Editor Wrinkle Department.

BRIEFLY TOLD.

THE COL. ROBERT GRIER MONROE MUNICIPAL LIGHTING BILL.—The Commissioner of Electricity, Gas and Water Supply for New York city, whose title and names are in the caption to this comment, seems to have met with serious opposition in the State legislature—the disaffection or dissatisfaction extended to and through both of the legislative divisions—to his proposal to construct and operate for public account in this city an electric lighting plant. The respective committees of the Senate and Assembly in initial charge of Colonel Robert Grier Monroe's measure have refused to report it, mainly on the ground that such authorization is against good public policy, wherefore the "Colonel," his aides "The Acorns" and Borough President Jacob Cantor are not in as good fettle over their suddenly conceived project as they were when they were "aborning it." However, some disappointment must come to all at one time or another, and this appears the time for such to visit the Colonel. Meanwhile we trust that "Jakie's" friends have not gone short of too many shares of Consolidated gas under 210. They may have a hard time covering without loss. The argument made in opposition to the municipal lighting scheme, which was put forth by Mr. John M. Bowers at Albany the 7th inst., was in his most masterful vein, and the full text of his pleadings can be found in the metropolitan newspapers, dated April 8th.

NOTES.—

LOCAL capitalists have under consideration the construction of a gas plant at Newton, Pa.

AT the annual meeting of the shareholders in the Essex and Hudson Gas Company, of Newark, N. J., the assemblage was much pleased at the progress made during the year, as shown by the annual reports. The net profits for the twelvemonth were quite near to $300,000, which sum represents not far from 4½ per cent. on the capital stock. During the year 34 miles of mains were put down and 42,000 services were put in and relaid; 13,000 gas appliances were sold, and 20 gas engines were put in service—the Company now supplies gas to 356 gas engines. The amount expended in betterments on the manufacturing and distributing divisions was in excess of $400,000. The officers elected were: Directors, John F. Shanley, George R. Gray, Thomas N. McCarter, Leslie D. Ward, Elisha B. Gaddis, James Smith, 3d, J. P. Dusenberry, Randal Morgan, Halsey M. Barrett, W. S. Davis, Spencer Weart, George Spottiswoode, Peter Hauck and Uzal H. McCarter; President, John F. Shanley; Vice-President, George R. Gray; Secretary and Treasurer, J. P. Dusenberry.

THE proprietors of the Mt. Joy (Pa.) Gas Company have increased the selling rate to $2 per 1,000 cubic feet.

THE works' men of the Cleveland (O.) Gas Light and Coke Company have been granted an increase of 15 cents per day in their rate of pay.

MR. J. H. OWENS is now in full charge of the management and operation of the plant of the Cadillac (Mich.) Gas Company.

MR. CARL H. GRAF, who recently resigned the position of Engineer to the Gas and Electric Company, of Bergen County, N. J., has been appointed Engineer-in-Chief of the many valuable gas properties owned by the Tilford-Lynn syndicate of this city. The headquarters of the syndicate are in the Lincoln Trust Company's building, 208 Fifth avenue.

MR. VERNON K. GOULD has assumed the Superintendency of the Bangor (Me.) Gas Light Company, succeeding Mr. Charles E. Dole, who resigned to devote his entire time to the development of his rapidly extending electrical business, chiefly in the construction line. Mr. Gould has acted as Assistant Superintendent to the Company since 1897.

THE proprietors of the Webster (Mass.) Electric Company, who are also in control of the gas supply of the district, have announced a reduction in the selling rates, the same to become operative the 1st prox. Under the new schedule gas will be sold on illuminating account at $1.85 per 1,000 cubic feet, the rate for a fuel gas supply being fixed at $1.45.

[OFFICIAL REPORT—REVISED BY THE SECRETARY.—CONTINUED FROM PAGE 530]

NINETEENTH ANNUAL MEETING, OHIO GAS LIGHT ASSOCIATION.

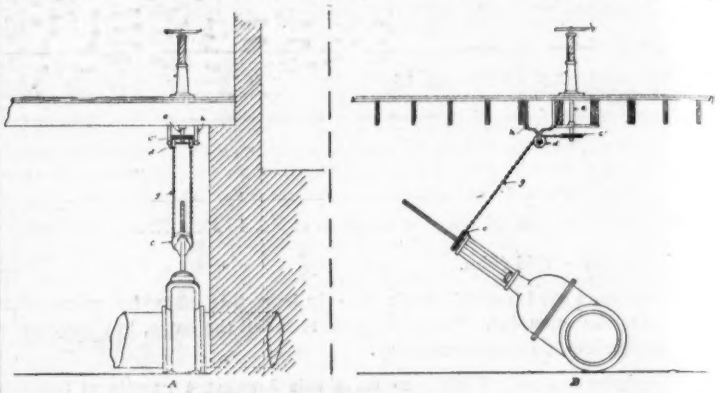
HELD IN THE GRAND HOTEL, CINCINNATI, O., MARCH 18, 19 AND 20, 1903.

FIRST DAY—MORNING SESSION.

WRINKLE DEPARTMENT.

The President introduced Mr. E. E. Eysenbach, of St. Paul, Minn., Editor of the Wrinkle Department, who presented the following:

No. 1.—*Valve Gear.*—Mr. V. L. Elbert, Superintendent of the St. Paul Gas Light Company, has given me a description of a valve gear that he is using very successfully at his works. This gear is especially



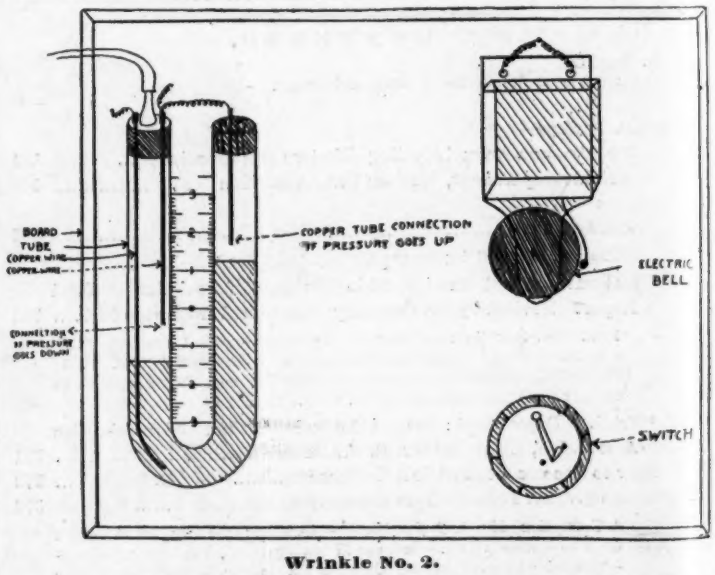
Wrinkle No. 1.

A, Side View; *B*, Cross Section; *C*, Single Differential Sheave; *D*, Groove Wheel; *E*, Valve Stem; *F*, Valve Stand; *H*, Hanger; *G*, Chain.

adapted for use where valves are not square with floor or on the same plane as valve stand. Also for any valve with inside or outside screw. The cut shows the latter. The sheave *C* has square hole in center and is placed over the brass nut of valve, the sheave *C*, Fig. 1, is left holed and drilled to fit valve stem. The chain is special steel link and can be obtained from any chain block factory. The groove wheels *d* are loose on the shaft, held in position by a steel pin in the axle; at every corner turned, two of these wheels are necessary. With the inside screw valve remove wheel from stem and place on sprocket wheel and proceed as per cut to complete.

No. 2.—*Electric Alarm Gauge.*—Mr. F. H. Shelton sends a description of a device, as fitted up and used by E. H. Grander, Assistant Superintendent of the Consolidated Schuylkill Gas Company, Royersford, Pa. The figure is self-explanatory.

An ordinary siphon gauge with rather large sized tubes is used.



Wrinkle No. 2.

Tubes are filled with water to which about 10 per cent. of sulphuric acid has been added. Battery is charged pretty heavy to overcome resistance of water. Natural gas companies have used this device, filling the tubes with mercury, which forms a better electric circuit, but is not nearly as sensitive a gauge as a water gauge.

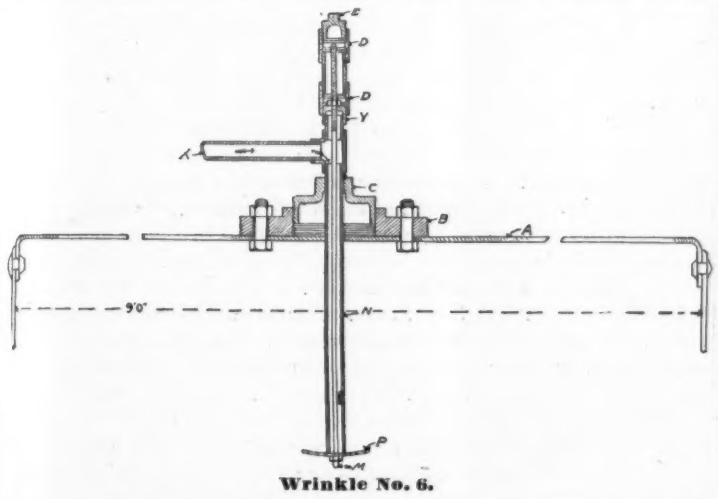
No. 3.—*Stand Pipe Jointing.*—Mr. F. C. Shepard, of Minneapolis, Minn., has used asbestos rope and found it a very successful substitute for fireclay and iron borings in common use for this purpose. It is quickly put in and easily removed, and makes a perfectly tight joint.

No. 4.—Mr. R. Shacklette, Manager of the Adrian (Mich.) Gas Company, writes as follows:

"All gas companies say that failure to receive bill does not entitle consumer to discount after regular discount period; each consumer should, therefore, be notified when he has no bill by sending regular bill with words NO BILL stamped on it." This would be very useful where no minimum charge is made.

No. 5.—*Ventilator for Double Floor Retort House.*—The large amount of steam which collected below the charging floor in the double floor retort house proved such a nuisance in cold weather that a 3-foot galvanized pipe was fastened on the wall of the house and carried up into the ventilators of the house. On the bottom of this pipe was put a hood slightly larger than the coke wagon. Coke is drawn into the wagon without quenching and is drawn under this hood to be quenched. The pipe carries off a great part of the steam, and a small steam coil in the bottom of the pipe induces a draft. This wrinkle was contributed by Mr. H. W. Douglas, Manager of the Ann Arbor (Mich.) Gas Company.

No. 6.—*Sprinkler for Scrubber.*—Contributed by Mr. V. S. Elbert, St. Paul (Minn.) Gas Light Company. Spray for Scrubber.—*A*, top of



Wrinkle No. 6.

scrubber; *B*, ordinary 4-inch flange; *C*, 4-inch plug tapped for ¾-inch pipe; *D*, ¾-inch coupling; *E*, ¾-inch plug; *N*, ¾-inch pipe; *M*, $\frac{3}{16}$-inch iron rod; *P*, circular copper plate—perforated; *X*, water connection from steam pump.

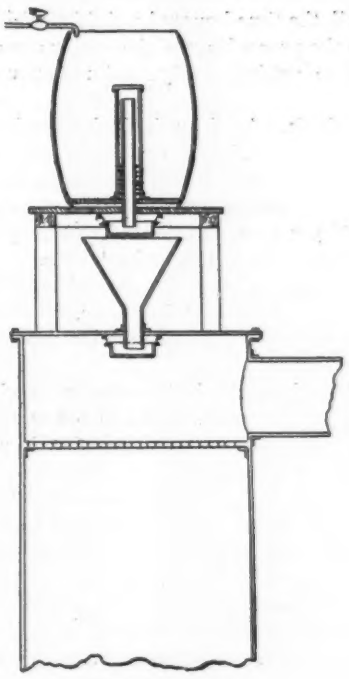
The hole drilled in cap *Y* should be large enough to allow the rod to vibrate. The lower end of pipe *N* should be as near top of scrubber as possible. Water entering at *X* fall to perforated plate causing plate to vibrate in ¾-inch pipe, causing water to spray towards the circumference of scrubber and perforations furnish water for the center. By altering the dish of the plate any desired distribution can be obtained.

No. 7.—*Automatic Intermittent Siphon Used for Flushing Scrubbers in Gas Works.*—A description of a similar device was contributed to this department by Mr. Baehr, of Denver, last year. This one, however, was not effected by the pressure in the scrubber, being entirely open to the atmosphere. A seal-pot is suspended from the under side of the top plate of scrubber. A similar seal-pot is placed under the barrel. A number of small openings at bottom of outer pipe allow the water to fill inner space between the two pipes and to flow down through the the inner pipe, starting the siphon. This wrinkle was contributed by Mr. Malone, Superintendent of the Madison (Wis.) Gas and Electric Company.

The Editor received very few contributions this year. "We have exhausted our supply of wrinkles by sending them to the Ohio and Western Association" writes Mr. Butterworth, President of the Denver Gas Company. This may be the experience of others; besides the business was so good during the year that instead of acquiring new wrinkles we probably lost some of the old ones. In this way only I can account for their scarcity.

Discussion.

The President—We all appreciate the amount of work performed by Mr. Eysenbach in getting together and presenting to us the many valuable suggestions contained in this Wrinkle Department. It undoubtedly



Wrinkle No. 7.

Sectional Diagram of Automatic Flush for Tower Scrubber. Scale ½ inch equals 1 foot.

has involved the expenditure of much time and labor. I will now call on the members for any discussion with reference to any special wrinkle. The Chair would be pleased to hear fron anyone who has anything to say by way of discussion on any of the wrinkles which you have heard read. If there are no questions or no discussion we will proceed with the regular order of business. Unfortunately, the Question Box papers have not arrived, owing to some delay on the part of the express companies. We will, therefore, have to leave that portion of the programme until later in our proceedings. We will now take up for consideration the paper by Mr. W. A. Baehr, of Denver, Colorado, entitled

THE CONSTRUCTION AND OPERATION OF RECUPERATIVE BENCHES.

As Mr. Baehr is not in attendance I will request Mr. Doherty to read it.

Mr. Henry L. Doherty then read the following:

In spite of the importance which is attached to the recuperative bench as one of the components of a gas works demanding the most serious consideration, very little attention seems to have been given the subject of late. I will endeavor to cover the principal points concerning the operation of such benches in the first part of this paper, and to draw such conclusions therefrom as will enable me to deduce certain lines of reasoning upon which to base the proper principles of construction.

In order to avoid the inevitable confusion arising from the use of terms not clearly understood, I will adopt the following definitions for use in this paper:

A recuperative bench is one in which both the primary and secondary air, or the secondary only, are preheated by passing through a flue, or set of flues, without reversal in direction, and continuously; the transfer of heat being accomplished *through* the walls of the flues.

A full-depth recuperative bench is one in which both the primary and secondary air are preheated.

A half-depth recuperative bench is one in which the secondary air only is preheated.

These definitions give absolutely no chance for any misunderstanding concerning the actual size in feet or inches of a bench, but show fundamental principles by which they can be readily distinguished.

Operation.—The first point which attracts our attention, and it is a very important one, is the proper regulation of the primary and secondary air. This matter is quite difficult to accomplish. The factor which determines the constancy of regulation is the resistance in the fuel bed, and this, as anyone can readily see, is subject to continual variation. The depth of fuel, its distribution and degree of fineness, and the varying accumulation of ash and clinker all influence the resistance very much. Of course, the fuel should be maintained as level as possible in order that the whole bed should act uniformly, and not have one portion of it worked harder than other parts, resulting in the formation of clinker.

There is only one accurate method to determine the correct adjustment of the primary and secondary air, and that is by flue gas analysis,

We have tried all the time honored wrinkles which have from time to time appeared in the proceedings of the various gas associations, but we never succeeded in getting really good results until we analyzed the waste gases.

Flue Gas Analysis.—As the principal ingredients of spent or flue gases are CO_2, CO, O and N, and a determination of the first three is all that is usually required for furnace regulation, three solutions only are necessary. The reagents used for the absorptions are as follows:

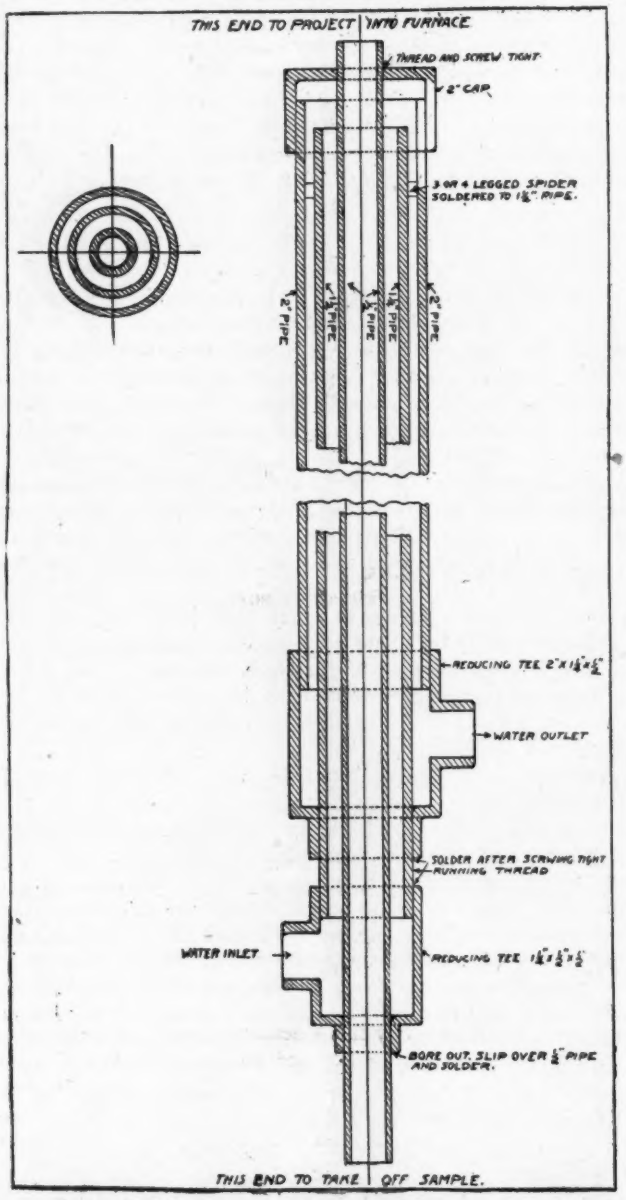
For CO_2. A 16 per cent. solution of caustic potash. This solution also absorbs H_2S and SO_2, if present in the gas.

For O. An alkaline solution of pyrogallic acid, $C_6H_3(OH)_3$. Dissolve 20 grm. of pyrogallic acid in 100 cc. of water. When about to use, mix some of this solution with its own volume of the potash solution.

For CO. A strongly acid solution of cuprous chloride. Dissolve 15 grm. of the red oxide of copper, Cu_2O, in 100 cc. of strong hydrochloric acid, specific gravity 1.19. Keep this solution in a glass stoppered bottle with scraps of metallic copper.

These reagents must be applied in the order given or they will absorb other gases besides the one intended, unless such gases were first removed. There have been a great many reagents recommended, but the above are the ones used by Prof. N. W. Lord, of the Ohio State University, who is an eminent authority on this class of work. Furthermore, it is highly important that the same kind of solutions be used, as any other solutions will introduce time and other factors, which will produce varying results.

In a very great many instances the gases to be analyzed are so hot that it becomes very difficult to secure samples. In such cases a water cooled tube used in connection with an aspirator is essential, and a design for such a tube is herewith appended. This design is made up of



ordinary pipe and fittings such as are on hand in every gas works. It is put together as follows:

The 2-inch cap is first tapped for a ¼-inch pipe thread in center. Then the required length of 2-inch pipe is cut and threaded at both ends and the tapped 2-inch cap screwed on tightly. Next, the ¼-inch pipe is screwed into the 2-inch cap as shown.

Now, separately from the above, the correct length of 1¼-inch pipe is screwed into the 2-inch reducing tee with a running thread. At the other end of the 1¼-inch pipe a spider is fastened, so as to be a loose fit inside the 2-inch pipe. Then the 1¼-inch pipe is lowered into the 2-inch pipe until the 2-inch reducing tee meets the end of the 2-inch pipe, and then it is screwed on tightly.

The only remaining thing is to put on the 1¼-inch reducing tee. This is readily done by boring out the ¼-inch end of this so as to slip over the ¼-inch pipe. The tee is then screwed home on the 1¼-inch pipe. Three joints then will have to be soldered as marked on this plan. This soldering is all right at these places for that end of the contrivance is not exposed to the heat. The following short descriptions of various kinds of apparatus for flue gas analysis will be of service to those who may wish to look up the subject.

In the Cooper tubes, or eudiometers, we have the simplest and cheapest of all gas analysis apparatus. A Cooper tube consists of a glass tube with a bulb at the closed end, and 2½ inches from the open end the tube is bent so that the short leg reverses in direction from the tube and forms an angle of 45° with it. Three sizes, called respectively 10 per cent., 25 per cent. and 50 per cent. tubes will be found sufficient for gas analysis.

The 10 per cent. tube is the one most generally used; it is 22½ inches in length, and its volume to the 1,000 mark on the leg is 200 cc. This volume is divided into 1,000 equal parts, of which 100 parts, or 10 per cent., is contained in the graduated portion of the leg. Hence the name —10 per cent. tube. The graduated portion of the leg is divided into 100 equal parts, beginning at 900 near the bulb and ending at 1,000 near the bent end. Each division indicates one part in 1,000, or practically one-tenth of 1 per cent. of the whole volume. In order to bring the gas to constant temperature and pressure after each absorption is made, the tube is placed in a large equalizing cylinder filled with water that has been in the room for some time.

The 25 per cent. and 50 per cent. tubes are arranged similarly to the above, except the percentage of the whole volume which is in the leg is 25 per cent. or 50 per cent. instead of 10 per cent. Gas analysis with these tubes is somewhat slow, due to the fact that the solution used for absorption must be removed and clean water run in to take its place before a reading can be taken in the equalizer. Anyone interested can find a full description of these tubes and how to use them in a paper[1] by Mr. O. O. Thwing, of St. Louis, read before the Western Gas Association in May, 1893.

For analysis of furnace gases only, the apparatus most generally employed is the Orsat-Muencke, or some one of its modifications. The Orsat-Muencke apparatus consists of 3 absorption pipettes and 1 water jacketed measuring burette complete in a travelling case.

The measuring burette has a capacity of 100 cc., and at its base is connected with a small bottle which contains water, brine, or mercury, by means of which the level of the liquid in the burette is raised or lowered so that the gases can be measured at atmospheric pressure. The top of the burette is connected by means of thick walled capillary tubes to the 3 absorption pipettes, the inlet to each being regulated by a cock and the outlet being connected to a relief vessel. The first pipette contains a caustic potash solution for the absorption of CO_2, the second an alkaline pyrogallic acid solution for O, and the third an acid solution of cuprous chloride for CO. All absorption pipettes are filled with fine tubes, so as to present a large surface of reagent to the gas. In the cuprous chloride vessel the tubes contain pieces of copper wire to keep the solution in the cuprous state.

The gas is drawn into the measuring burette and 100 cc. of it are retained at atmospheric pressure and temperature. By raising the small bottle the gas is forced into the first pipette and the CO_2 absorbed, then it is drawn back and measured, the loss in volume being the percentage of CO_2 present, and the process is continued in a similar manner for the other constituents.

Another simple, but very accurate, form of gas analysis apparatus is that known as the Hempel. It consists of a measuring burette and correction tube surrounded by a large water jacket. At the bottom of the measuring burette a regulating bottle or bulb is attached. There is included a series of absorption pipettes, one for each gas or combination of gases. The inlets and outlets of each pipette are made of heavy walled capillary tubes. Each pipette, after receiving the gas from the measuring burette, can be detached, and thus the gas and the absorb-

1. "Gas Analysis," JOURNAL, June 12, 1893; p. 848.

ing solution can be thoroughly agitated, producing a very rapid and complete absorption of the gas which is to be removed. Then the pipette is again attached to the measuring burette, the gas drawn back, and a reading taken at constant temperature and pressure. This process is then repeated for the other constituent gases.

There are many other forms of gas analysis apparatus, among which may be mentioned Elliott's and Bunte's, and descriptions of these can be found in any of the trade catalogues of firms who deal in chemical apparatus. I gave the above outline descriptions of the apparatus in common use, because the importance of flue gas analysis demands it, and to direct such people who are intending to begin this kind of work to the best and most reliable methods of securing their results.

Since all the usual gas analysis apparatus give results by volume, and it is customary to give final results in per cent. by *weight*, it is necessary to reduce the per cent. by volume to per cent. by weight. This is most readily done by multiplying the percentage of each constituent gas by volume, by the density of that gas, then divide this product by the sum of the products of the multiplication of all constituents. Each quotient will then give the percentage by weight for that particular gas. As the volume of a gas changes with variations of atmospheric pressure and temperature, it is necessary, in order to obtain a standard for comparison, to reduce all volumes as measured to the volume which that quantity of gas would occupy at sea level atmospheric pressure, which is 760 millimeters of mercury, and also to 0°.

The following formula may be used to make these corrections:

V = the measured volume of gas.
t = temperature of this gas in degrees Centigrade.
p = atmospheric pressure at which the measurement was taken.

$$\text{Then the corrected volume} = \frac{V \times 273 \times p}{760 \times (273 + t)}$$

The theoretical yield of CO_2 should be approximately 21 per cent. by weight. To balance the analysis, after reducing it to per cent. by weight, sum up all the oxygen in the CO_2, CO, and O present and compare it to the nitrogen. Atmospheric air contains very nearly 77 parts by weight nitrogen, and 22 parts by weight oxygen. From this relationship, which must necessarily hold true, the balance of any flue gas analysis can be derived. If the nitrogen is not present in the ratio of 3.34 parts for every 1.0 parts of oxygen, you may conclude your analysis is wrong.

Calorimetry.—Why do we take such pains to make careful flue gas analyses, and to watch our draft with a hawk's eye, and still neglect the source from which we obtain our heat? How many of us know from day to day the calorific value of the coal or coke we are firing in our bench furnaces and under our boilers? Most of the gas companies, and I may safely include the electric companies, contract for a certain kind of coal each year. This is generally of a variety such as would suit their conditions, and if the coal companies constantly furnished the grade specified all would be well. But do they? Are they giving us the calories we are paying for? If not, how do *we* know they are not? Where does the burden of the blame lie?

There is only one way to settle this vexed question and that is by daily calorific determinations. And to that end I suggest that in every company the superintendent be furnished with a daily report showing the calorific values of the fuels fired the preceding day, the flue gas analyses from hourly or bi-hourly observations, and finally the *heat efficiency* of every furnace and of every apparatus that utilizes or transforms heat into other forms of energy. Here is the keynote of success or failure, the real and unfailing standard by which to gauge the performance of any machine. The heat efficiency—how many engineers there are who do *not* reduce their observations to this basis; *very few do.* I am afraid that altogether too few of us realize that all energy, whether chemical, mechanical, electrical or in other forms, is directly reducible and comparable on a heat basis.

Our scrubber efficiencies, which result directly from the chemical actions taking place therein, are readily reducible to heat reactions. Our condensers and purifiers should be rated in the same way. Our boilers, water gas plants, coal gas benches, in fact every apparatus used for transforming one kind of energy to another, should and can be treated as a heat machine.

In this paper I will treat recuperative benches purely from a heat standpoint. In order to give an idea of the various steps leading up to the subject it is necessary to include calorimetry and mention the different makes of machines. I will only give their names, as this paper would become too long otherwise. Full descriptions can be found in the catalogues of dealers.

Various Makes of Calorimeters.—The Carpenter, Parr, Mahler bomb, Favre and Silberman, Scheurer-Kestner, Meunier-Dollfus, Berthelot, Alexejew, Fischer, Thomsen, Schwackhofer, W. Thompson, Barrus, Hartley and Junker, Lewis Thompson, Andrews, Berthelot and Violle, Atwater Krocker, Hempel, Walther-Hempel, Witz, Hermann, Herschel, Bunsen, Schulla and Wartha, Von Tham and Dieterici.

Full descriptions of the method of operating these can be found in the "Calorific Power of Fuels," by Herman Poole. The Mahler bomb, the Carpenter, and the Parr are the most extensively used.

Specific Heat of Gases.—Before reaching the main portions of this paper it is necessary to give thorough consideration to one more preliminary subject, viz.: The specific heat of gases at various temperatures. During some years of study on "Heat" there has been no more difficult or abstruse problem presented to me than this same subject. In the first place there are very few authorities who say anything at all about it, and those that do give the most remarkable series of variable and contradictory statements one could well imagine.

The ordinary text and reference books on physics give tables of the specific heat of gas at constant pressure and at constant volume, but say nothing which would lead one to suppose that these gases had a thermal capacity varying with the temperature. In fact I feel safe in saying that the average engineer, or college man, does not know that such a variation exists.

In the "Chemiker-Kalendar," by Dr. Rudolph Biedermann, published in Berlin, Germany, the tables of specific heat of gases are expressly stated to be true only between certain ranges of temperature. To show some of the research work done on this subject I will quote the following from "Nernst's Theoretical Chemistry," beginning on page 34. In this extract the temperatures are quoted in degrees Centigrade:

"A number of French investigators have recently succeeded in determining the specific heats of gases at very high temperatures with quite a considerable degree of accuracy. Mallard and Le Chatelier (*Compt. Rend.*, 93, 1,014, 1,076, 1881) exploded a gas mixture of known composition in a closed iron cylinder, and determined the maximal pressure developed thereby. This last measurement was performed at first with a Bourden's manometer, which recorded its data by means of a needle on an evenly rotating cylinder. Later these same investigators employed the crushing manometer constructed by Sarreau and Violle (ibid., 95. 26, 1882, on which the pressure was measured by the permanent deformation of a small, solid, copper cylinder placed between an anvil face and a piston, on which the pressure to be determined acted; also, here the time occupied in developing the pressure was determined by means of a needle and a rotating cylinder. Thus by measuring the maximal temperature, and since the heat developed by the explosion is known from the thermochemical data, there is given at once the heat capacity of the gas mixture. A correction must be made to account for the heat given off from the walls of the explosion bomb, which on account of the quick occurrence of the explosion is inconsiderable; this correction can be calculated from the velocity of cooling observed by the decrease of pressure after the explosion, or it can be determined quite accurately in the experimental way by the use of various large receiving vessels."

From the fact that the maximal pressure of a gas mixture, for example "knall gas," when exploded with admixture of equal volumes of nitrogen or oxygen, or hydrogen, or carbon monoxide, experiences the same diminution of temperature, it follows that *these gases possess the same heat capacity up to the maximal temperature of explosion; i. e. up* 2,700°. This is true, provided that these gases have the same co-efficient of expansion up to these temperatures, something which can scarcely be doubted after the measurements of V. Meyer and Langer (Pyrochem. Unterss., Braunschweig, Bruesswick, 1885).

These results have been confirmed as well as broadened at several points by Violle (*Comp. Rend.*, 96. 1,358, 1883), and also by Berthelot and Violle (ibid. 98. 545, 601, 770, 852, 1884). It was shown later that nitrogen and carbon monoxide have the same heat capacity, by the explosion of a mixture of cyanogen and oxygen, which led to the formation of carbon monoxide and nitrogen; thus

$$C_2N_2 + O_2 = N_2 + 2CO.$$

From the heat developed by this reaction and the maximal temperature observed, there could be calculated the specific heats of nitrogen and carbon monoxide. Finally, from further researches which were conducted with an excess of nitrogen, there could be stated the following formula for the molecular heat of N_2, H_2, O_2, and CO at constant volume, and which can be regarded as good from 1,600° to 4,500°; viz.:

$$4.75 + 0.0032\ (t - 1{,}600).$$

For the latter temperature, 4,500°, this formula gives 14.1; *i. e.*, the

molecular heat of the permanent gases increases very considerably with the temperature.

From observation on the maximal pressure in the explosion of hydrogen and carbon monoxide, in the presence of varying quantities of nitrogen, Berthelot and Violle calculated the molecular heat of the water vapor to be

$$16.2 + 0.0038\ (t - 2{,}000),$$

and for that of carbon dioxide

$$19.1 + 0.0030\ (t - 2{,}000).$$

Both formula refer to the molecular heat at constant volume.

Later, Mallard and Le Chatelier ("Wied. Beibl.," 14.364, 1890), used in a very similar way the maximal pressures of various explosives as observed by Sarreau and Violle, to calculate the speeific heats of gases, and thus obtained results showing undoubtedly that the molecular heats of the "permanent" gases increase strongly at higher temperatures. For the mean molecular heats at constant volume between 0° and t° they found:

Carbon dioxide	6.50 + 0.00387 t.
Water vapor	5.78 + 0.00287 t.
Permanent gases	4.76 + 0.00122 t.

At the same time they found that the molecular heat was independent of the pressure itself, at pressures of 6,000 to 7,000 atmospheres.

The Dependence of the Specific Heat of Gases on the Temperatures.—It has already been repeatedly shown that the specific heat of gases steadily decreases with decreasing temperature (the apparent exceptions exhibited by the vapors of acetic acid and of nitrogen dioxide at certain temperature intervals have been referred to the dissociation phenomena).

As Le Chatelier noticed ("Zeitschr. Phys. Chem.," 1. 456, 1887.) this decrease indicates a tendency for the specific heats of the most different gases to approach *the closer, the more the temperature sinks, and at absolute zero the values of the molecular heats at constant pressure seem to converge at* about 6.5. The observations, therefore, can be represented by the formula,

$$Cp = 6.5 + aT,$$

in which *T* represents the absolute temperature, and *a* represents a coefficient which is greater according as the molecule is *more complex.*

The following values have been calculated for *a:*

H_2, N_2, O_2, CO	0.0010
NH_3	0.0071
CO_2	0.0084
N_2O	0.0089
C_2H_4	0.0137
$CH\,Cl_3$	0.0305
$C_2\,H_5\,Br$	0.0324
$C_2\,H_6\,O$	0.0403
$C_6\,H_6$	0.0510
$CH_3\,COOC_2\,H_5$	0.0674
$(C_2\,H_5)_2\,O$	0.0738

If, for example, one calculates the mean specific heats measured by E. Wiedemann between 20° and 200°, with the help of the formula given above, he will find very good agreement. Also the values found by Le Chatelier at very high temperatures (as above) are in good agreement, since the true molecular heats at constant pressure, calculated for —273°, for the following substances are:

CO_2	6.39
H_2O	6.22
H_2, N_2, CO_2, O_2	6.10

All are nearly equal and not far removed from 6.5.

The above extract from "Nernst's Theoretical Chemistry" gives the present state of knowledge, and some of the experiments performed to determine the specific heat of gases at high temperatures. A number of other investigators, some of high repute, have worked on this problem from time to time, but unfortunately their results do not present the uniformity of conclusions so much desired. I cannot enumerate all this research work, but a few instances are mentioned in the "Chemiker-Kalendar" for 1902, and several articles on high temperature work have appeared in the scientific journals during 1902, giving descriptions of experiments performed along these lines.

After looking through a large number of standard works of reference, and writing to several college professors of high standing, none of whom could give me the tables I sought, I was about to give up hopes, when it occurred to me that perhaps Mr Fred. Bredel, of Milwaukee, could give me some information on the specific heat of gases at various temperatures. Mr. Bredel read two very able papers in 1892 bearing on the same subject as this paper, one[1] before the Ohio Gas Light Association entitled "The Determination and Regulation of the Proper Proportions of Primary and Secondary Air and Steam in Regenerative Furnaces," and the other[1] before the Western Gas Association, entitled "The Advantages of Recuperative Furnaces in the Utilization of Heat." I wrote to Mr. Bredel for what information he could and would give me, and great indeed was my pleasure at receiving the following reply:

"MILWAUKEE, WIS., Jan. 16, 1903.

"Mr. W. A. Baehr, Superintendent Gas Department, The Denver Gas and Electric Company, Denver, Col.—My Dear Sir: I herewith send you a diagram showing the specific heats. Most of them are calculated by myself and corrected to date. I have found that they are practically correct and give the average of all compilers where actual experiments have been made. I figured them out theoretically.

"If in your article you want to mention the temperatures I wish you would mention the way I got at them. I compiled same from different authorities to as high a heat as actual experiments have been made, then found out the coefficient of increase and then checked back. Naturally the moment you would touch the dissociation point, something entirely different would happen; but as that is only just reached in the instance of water vapor in actual firing the figures can be taken as correct, as they stand. The proof that the thing is very closely correct is that in theoretically figuring high temperatures by means of this table they coincide with temperatures that have been measured, and this I consider the main check of their correctness. The actual calculations, unhappily, have been mislaid by me, and only the original diagram, as drawn by me, is left; and some of the figures have been proved to be correct since, where actual experiments have been made, and the table should stand as it is.

"I have set the table up from time to time as in the different scientific journals results were published, and I have never found any large discrepancy. There have been some where the discrepancy has been quite a little, but which we afterwards found out to be incorrect.

"Yours truly, (Signed) FRED BREDEL."

This diagram,[2] which gives the specific heat of some gases in terms of the Centigrade scale, and which was furnished me through the courtesy of Mr. Bredel, I append to this paper. I also append a small diagram giving the same information on a reduced scale.

Heat Reactions and Effect of Using Varying Quantities of Water on the Thermal Efficiency.—There is no question but that the water used in the furnaces to prevent clinkering has an important bearing on furnace operation. There should be enough water vaporized to keep the temperature of the fuel bed below the clinkering point, but in most works there is probably considerable excess water used. The correct quantity can be determined experimentally, by starting with a large excess of water, and gradually cutting it down until clinkers just begin to appear, or *vice versa* After the correct amount has once been determined it should be closely adhered to, and this can be done in the following way:

In the first place the water must be supplied with a uniform head. At Denver we formerly used surface water, but this corroded the pipes and stopcocks so fast that an adjustment of flow would not hold good an hour. We thereupon changed our system to the artesian water supply, put in new petcocks, and the trouble has disappeared. There is an overhead tank fitted with a float-governed valve, in which the water keeps at a constant level. From this tank the leads run to the various stacks.

We figure the amount of water down to cubic centimeters per minute, and then by means of a graduated burette and a stop-watch we take a reading every day on each bench. By adjusting the petcock the correct amount is readily supplied.

Another important point in this connection is that if all the retort house men are allowed to tamper with the air slides, water supply, and general furnace regulation, all the analyses of flue gases and calorimeter determinations that one-half dozen chemists could make would be of no avail. All this should be left in the hands of the retort house foreman, and he should change adjustments only after proper tests have been made.

Pyrometer Tests.—We procured a Heraeus Le Chatelier pyrometer from Mr. Charles Engelhard, 41 Cortland street, New York City, and made a great many temperature determinations in our benches. This pyrometer cast $150, and is without doubt the nicest instrument for making high temperature determinations on the market to-day. The elements used are platinum and platinum-rhodium.

In order to secure reasonably correct temperatures we adjusted a bench

1. See JOURNAL, April 18, 1892, p. 558.

1. See JOURNAL, June 27, 1892, p. 908.

2. The diagrams were not fowarded.—EDS.

until the flue gas analysis was very good, and then took readings. The following temperatures resulted:

Temp. just above fire in furnace	1,950° to	2,050° F.
" in combustion chamber, 2 feet above nostrils.		2,440° F.
" in combustion chamber, 4 feet above nostrils.		2,470° F.
" of waste gases at top of recuperator		1,475° F.
" of waste gases at bottom of recuperator		750° F.

Of course the temperatures vary somewhat from the front to the back of the benches, but we made several determinations at varying distances from the front with the foregoing average results. In view of these tests I will use the following temperatures in my calculations:

Temp. just above fire	2,000° F.
" in combustion chamber	2,500° F.
" of waste gases top of recuperator	1,500° F.
" of waste gases bottom of recuperator	750° F.

Our benches are full-depth recuperative benches of sixes, with retorts 15 by 26 inches and 9 feet long, inside.

I will now give various estimates of bench efficiencies, and in order to simplify the figuring, I will use the following specific heats:

CO_2	.2164	Heats of combustion.
N	.244	C to CO_2 = 14,544 B. T. U.
Air	.2379	C to CO_2 = 4,400 "
H_2O vapor	.48	CO to CO_2 = 4,348 "

The following computation shows the theoretical efficiency of a full-depth bench as compared to a half-depth bench, using *no* water in the furnaces:

For full-depth bench:

Heat Produced.

1 pound C with 2.66 pounds O and 8.88 pounds N. to 3.66 pounds CO_2 and 8.88 pounds N. = 14,544 B. T. U.

Losses.

3.66 pounds CO_2 from 60° to 2,500° F. = 3.66 × .2164 × 2,440	=	1,932 B. T. U.
8.88 pounds N. from 60° to 2,500° F. = 8.88 × .244 × 2,440	=	5,287 "
Gross loss	=	7,219 "

recovered by absorption in secondary air, which would be 5.77 × .2379 × 2440 = 3,349 B. T. U.

The flue gases would have a specific heat of .236 and the temperature of the escaping gases at the bottom of the flues where secondary air is admitted would be

$$2,500° - \frac{5.77 \times .2379 \times 2,440}{12.54 \times .236} = 2,500° - \frac{3,349}{2.959} = 2,500° - 1,132° = 1368° \text{ F.}$$

Then the heat recovered by absorption in the primary air would be 5.77 × .2379 × (1,368 — 60) = 1,795 B.T.U.

The final temperature of the escaping gases would be

$$1,368° - \frac{5.77 \times .2379 \times 1,308}{12.54 \times .236} = 1,368° - \frac{1,795}{2.959} = 1,368° - 606° = 762° \text{ F.}$$

Then the net loss of heat = 7,219 — (3,349 + 1,795) = 2,075 B.T.U.

Therefore, the theoretical efficiency of a full-depth bench, not allowing for radiation, opening of doors, etc., would be (14,544 — 2,075) ÷ 14,544 = 85.73 per cent.

For a half-depth bench the heat produced and the gross losses are the the same as for a full-depth bench, as is also the heat recovered by absorption in the secondary air. But there would be no recovery in the primary air, and, therefore, the net loss for a half-depth bench would be 7,219 — 3,349 = 3,870 B.T.U.

The theoretical efficiency, with previously mentioned omissions, for a half-depth bench would then be (14,544 — 3,870) ÷ 14,544 = 73.39 per cent.

Now, in order to show the efficiency of a half-depth bench using varying quantities of water, I will give below the calculations when using

1 pound water for every 10 pounds C.
1 " " " 8 "
1 " " " 6 "
1 " " " 4 "

1st: 1 pound water for every 10 pounds C:

Heat Produced.

9⅛ pounds C. burned with 107.71 pounds air (82.88 pounds N) to 34.16 pounds CO_2 = 9⅛ × 13.544.	=	135,744 B. T. U.
⅜ pounds C burned with 1 pound H_2O (⅛ pounds H) to 1⅜ pounds CO = ⅜ × 4,400	=	2,934 "
1⅜ pounds CO. burned with 3,865 pounds air (2,976 pounds N) to 2⅜ pounds CO_2 = 1⅜ × 4,348	=	6,764 "
Total heat of combustion	=	145,442 "

Losses.

1 pound H_2O from 60° to 212° F	=	152 B. T. U.
1 pound H_2O, latent heat of vaporization	=	966 "
1 pound H_2O entering flues at 2,500° F. = 1 × .48 × 2,440	=	1,171 "
36.6 pounds CO_2 entering flues at 2,500° F. = 36.6 × .216 × 2,440	=	19,325 "
85.856 pounds N entering flues at 2,500° F. = 85.856 × .244 × 2,440	=	51,115 "
2.976 pounds N entering flues at 2,500° F. = 2.976 × .244 × 2,240	=	1,772 "
Gross loss	=	74,501 "

Recovered by absorption in secondary air, which is

⅛ of 107.71 = 53.85 pounds to burn 9⅛ pounds C to CO_2 and
3.865 " " 1⅜ " CO to CO_2 and
3.865 " " ⅛ " H to H_2O.

Total = 61.58 pounds air.

Heat absorbed = 61.58 × .2379 × 2,240 = 35,746 B. T. U.

Then the net loss = 74,501 — 35,746 = 38,755 B. T. U.

Efficiency = (145,442 — 38,755) ÷ 145,442 = 73.35 per cent.

This would give the flue gases a specific heat of .238 and the temperature of the escaping gases would be

$$2,500° - \frac{61.58 \times .2379 \times 2,440}{126.4 \times .238} = 2,500° - \frac{35,746}{30.083} = 2,500° - 1,188 = 1,312° \text{ F.}$$

These estimates, of course, do not allow for radiation, opening of doors, etc.

2d: 1 pound water for every 8 pounds carbon.

Heat Produced.

7⅛ pounds C burned with 84.63 pounds air (65.12 pounds N) to 26.84 pounds CO_2 = 7⅛ × 14,544.	=	106,656 B. T. U.
⅜ pounds C. burned with 1 pound H_2O (⅛ pound H) to 1⅜ pounds CO = ⅜ × 4,400	=	2,934 "
1⅜ pounds CO burned with 3.865 pounds air (2.976 pounds N) to 2⅜ pounds CO_2 = 1⅜ × 4,348	=	6,764 "
Total heat of combustion	=	116,354 "

Losses.

1 pound H_2O from 60° to 212° F	=	152 B. T. U.
1 pound H_2O, latent heat of vaporization	=	966 "
1 pound H_2O, entering flues at 2,500° F. = 1 × .48 × 2,240	=	1,171 "
29.28 pounds CO_2 entering flues at 2,500° F. = 29.28 × .2164 × 2,440	=	15,460 "
68.096 pounds N entering flues at 2,500° F. = 68.096 × .244 × 2,440	=	40,542 "
2.976 pounds N entering flues at 2,500° F. = 2.976 × .244 × 2,440	=	1,772 "
Gross loss	=	60,063 "

Recovered by absorption in secondary air. which is

⅛ of 84.63=42.31 pounds to burn 7⅛ pounds C to CO_2, and
= 3.865 " 1⅜ pounds CO to CO_2, and
= 3.865 " ⅛ pounds H to H_2O.

Total = 50.04 pounds air.

Heat absorbed = 50.04 × .2379 × 2,440 = 29,047 B. T. U.

Then the net loss = 60,063 — 29,047 = 31,016 B. T. U.

Efficiency = (116,354 — 31,016) ÷ 116,354 = 73.34 per cent.

This would give the flue gases a specific heat of .240, and the temperature of the escaping gases would be

$$2,560° - \frac{50.04 \times .2379 \times 2,440}{101.32 \times 24} = 2,500° - \frac{29,047}{24.32} = 2,500° - 1,194° = 1,306° \text{ F.}$$

3rd. 1 pound H_2O for every 6 pounds C.

Heat Produced.

5⅛ pounds C burned with 61.55 pounds air (47.36 pounds N) to 19.52 pounds CO_2=5⅛ × 14,544	=	77,568 B. T. U.
⅜ pound C burned with 1 pound H_2O (⅛ pound H) to 1⅜ pounds CO=⅜ × 4,400	=	2,934 "
1⅜ pounds CO burned with 3.865 pounds air (2.976 pounds N) to 2⅜ pounds CO_2=1⅜ × 4,348	=	6,764 "
Total heat of combustion	=	87,266 "

Losses.

1 pound H_2O from 60° to 212° F	=	152 B. T. U.
1 pound H_2O, latent heat evaporation	=	966 "
1 pound H_2O, entering flue at 2,500° F.=1×.48×2,440	=	1,171 "
21.96 pounds CO_2 entering flues at 2,500° F. = 21.96 × .2164×2,440	=	11,595 "
50.336 pounds N entering flues at 2,500° F.=50.336 × .244 + 2,440	=	29,968 "
2.976 pounds N entering flues at 2,500° F.=2.976 × .244 × 2,440	=	1,772 "
Gross loss	=	45,624 "

Recovered by absorption in secondary air, which is

$\frac{1}{3}$ of 61.55 = 30.78 pounds to burn $5\frac{1}{3}$ pounds C to CO_2, and
3.865 " " $1\frac{5}{9}$ " CO to CO_2, and
3.865 " " $\frac{1}{9}$ " H to H_2O,

Total.....=38.51 " air.

Heat absorbed = 38.51 × 2,379 × 2,440 = 22,354 B. T. U.
Then the net loss = 45,624 — 22,354 = 23,270 B. T. U.
Efficiency = (87,266 — 23,270) ÷ 87,266 = 73.33 per cent.

This would give the flue gases a specific heat of .239, and the temperature of the escaping gases would be

$$2{,}500° - \frac{38.51 \times .2379 \times 2{,}440}{76.24 \times .239} = 2{,}500° - \frac{22{,}354}{18\ 22} = 2{,}500° - 1{,}227° = 1{,}273° \text{ F.}$$

4th. 1 pound H_2O for every 4 pounds carbon.

Heat Produced.

$3\frac{1}{3}$ pounds C burned with 38.47 pounds air (29.6 pounds N) to 12.2 pounds $CO_2 = 3\frac{1}{3} \times 14{,}544$...	=	48,480 B. T. U.
$\frac{2}{3}$ pound C burned with 1 pound H_2O ($\frac{1}{9}$ pound H) to $1\frac{5}{9}$ pounds CO = $\frac{2}{3} \times 5{,}400$.....	=	2,934 "
$1\frac{5}{9}$ pounds CO burned with 3.865 pounds air (2.976 pounds N) to $2\frac{4}{9}$ pounds $CO_2 = 1\frac{5}{9} \times 4{,}348$.....	=	6,764 "
Total heat of combustion.....	=	58,178 "

Losses.

1 pound H_2O from 60° to 212° F.....	=	152 B. T. U.
1 pound H_2O latent heat of vaporization.....	=	966 "
1 pound H_2O entering flues at 2,500° F. = 1 × .48 × 2,440..	=	1,171 "
14.64 pounds CO_2 entering flues at 2,500° F. = 14.64 × .2164 × 2,440.....	=	7,730 "
32.576 pounds N entering flues at 2,500° F. = 32.576 × .244 × 2,440.....	=	19,394 "
2.976 pounds N entering flues at 2,500° F. = 2.976 × .244 × 2,440.....	=	1,772 "
Gross loss.....	=	31,185 "

recovered by absorption in secondary air, which is

$\frac{1}{3}$ of 38.47 = 19.24 pound to burn $3\frac{1}{3}$ pounds C to CO_2, and
= 3.865 " " $1\frac{5}{9}$ " CO to CO_2, and
= 3.865 " " $\frac{1}{9}$ " H to H_2O.

Total .... = 26.97 " air.

Heat absorbed = 26.97 × .2379 × 2,440 = 15,655 B. T. U.
Then the net loss = 31,185 — 15,655 = 15,530 B. T. U.
Efficiency = (58,178 — 15,530) ÷ 58,178 = 73.31 per cent.

This gives the flue gases a specific heat of .240, and the temperature of the escaping gases will be

$$2{,}500° - \frac{26.97 \times .2379 \times 2{,}440}{51.16 \times .24} = 2{,}500° - \frac{15{,}655}{12.28} = 2{,}500° - 1{,}275° = 1{,}225° \text{ F.}$$

I wish to state frankly that the reason for using the commonly accepted specific heats of gases in the foregoing calculations, instead of getting the mean coefficients of thermal capacity from Mr. Bredel's diagram, was not only to make the work easier, but for a far more important object. This object is as follows: There is to day no longer any question but that the specific heat of gases varies at different temperatures, but there is no authority as yet whose coefficients have been universally checked and accepted. Mr. Bredel deserves great credit for his attempt to get at the truth, but as he himself admits that the main check of the correctness of his diagram comes from the agreement of certain observed temperatures with the temperatures calculated by aid of it, I feel that further and more scientifically accurate experiments must be made before we can accept his results.

Now it will be observed that in the previous calculations of the heat reactions taking place in a *full*-depth bench with no water used in the furnaces that the final temperature figures out as 762° F. This is not far from what it should be, according to actual measurements.

Construction of Benches.—From the foregoing discussion certain obvious deductions as to construction necessarily follow. The first point arising is the

Shape of the Furnace.—Since that geometrical figure which possesses the greatest area for the least length of enveloping line is the circle, it follows that furnaces should have a circular, horizontal cross section theoretically in order to get the least wall surface. However, in practical bench construction, this shape is not feasible except in producer firing, in which case the producer can certainly be made circular.

In practical bench construction various considerations require that furnaces should be rectangular in shape. Now, in order for any right-angled figure to have the largest area for the least perimeter it must be a square. Again, practical considerations step in and require that the furnace be longer than it is wide. But the perimeter of any rectangle grows less as it approaches a square; that is, of course, for the same area. From this it readily follows that the furnaces should be made as wide as possible, consistent with construction requirements; or in other words, that it should approach a square as nearly as may be.

Further, narrow furnaces are very uneconomical and hard to operate. That this is true will appear from the following discussion on the

Effects of Uneven Distribution of Fuel.—It seems almost an axiom to me that the fuel should be distributed evenly. By this I mean not only that it shall present a horizontal upper surface, but also that it shall be as nearly as possible a homogeneous mass. Of course, if the grate bars are inclined the upper surface of the fuel should be parallel to them. A fuel bed cannot be homogeneous if here and there large lumps occur in it, interspersed with varying masses of finer material, or lumps of clinkers.

Now an uneven fuel bed naturally possesses varying resistance in its different parts. The least resistance is apt to occur along the wall, hence the less wall the better for any given area. Further, the back of the furnace generally has a shallow fuel bed. It is a comparatively simple matter for the retort house foreman to insist that after every firing the fuel bed should be levelled with a poker. Since the velocity of the air passing through the fire results from the differential pressure above and below it, and also from the resistance it encounters, it is certain to have a high velocity in places of low resistance, and a low velocity in places of high resistance. What is the result? It is simply this: Where high velocity occurs the carbon in the fuel burns directly to CO_2 and remains CO_2 through the bed, or at least in a great measure. This means a high flame temperature, so high that the ash is fused and clinkers result.

It is well established that the reactions taking place in a producer are that the lower carbon burns to CO_2. This, on passing up through the fuel bed, is reduced to CO by taking on an atom of carbon. This reduction absorbs heat. Therefore the temperature must be lowered.

Now the heat is a form of energy. It is another oxiom in physics that no matter how great the force (or energy) exerted on a mass of matter however small it takes a finite length of time to start motion. Applying this axiom to the above dissociation of CO_2 into CO, we see that no matter how great the heat (energy force), nor how small the mass of CO_2, it must take a finite length of time to effect the reduction.

Thus we see that the question resolves itself as depending for one thing on the velocity of the air through the fire. Just what that velocity is I do not know, but I do know that when there is a very shallow spot in the fire we get large quantities of CO_2 above the fuel bed and this has already done mischief by producing clinkers, and can do no good at the retorts because it cannot burn, and its only and slight value is to heat the incoming secondary air, both in the combustion chamber and through the recuperator walls by its sensible heat.

A long, narrow furnace inevitably has a shallow fire in the back; it has the longest perimeter for a given area; the fuel caches or arches across it, due to the proximity of the side walls; the water is hard to distribute; it clinkers badly; is harder to clean, and, to use a slangy but highly expressive phrase, "It doesn't deliver the goods."

Since the fuel at the bottom of the fire burns directly to CO_2 a local high temperature is there produced. This is prevented by vaporizing water, and this vapor, due to its high co-efficient of thermal capacity and high dissociation temperature, prevents clinkering. This very prevention of clinkers is a loss of heat, and, therefore, the efficiency of using water is not 100 per cent. even though the hydrogen burns back to water. Therefore, only enough water should be used to prevent fusing and not a drop more.

Grate Area.—Depth of Fuel.—Producer practice, which in one sense of the word is farther along scientifically than illuminating gas bench construction, has determined that 12 pounds of coal per square foot of grate area per hour is about the limit of good practice. Gas engineers could well study this problem before jumping into designs. Owing to the fact that furnace cross sections are usually rectangular, thereby greatly increasing the wall surface per square foot of grate area over what it would be with a circular cross section, I doubt if it is safe to figure on a value exceeding 8 pounds of *carbon* per square foot of grate area per hour. The grate area, therefore, should probably be designed on this basis, or very near it. In regard to the depth of a fire it should be just deep enough to convert all the CO_2 into CO. This will become apparent from the following discussion on

Flue Design.—The fundamental requirement of the flues is that they present the least resistance possible, on account of leakage between the air and gas flues. This also affects the fire bed depth, as that constitutes a portion of the resistance. In other words, the fire should be as shallow and the flue as large in cross section as possible.

Leakage varies directly as the perimeter and as the square root of the

pressure. By doubling the perimeter, length remaining the same, we double the leakage, but by doubling the pressure we only increase the leakage approximately 41 per cent. The leakage curve for increments of perimeter would be a straight line, while that for increments of pressure would probably be a parabola. By plotting both these curves on one sheet, and bearing in mind that the pressure would be greatest for the least perimeter, and *vice versa*, it seems reasonable to assume that the point where the two curves crossed would give the proper flue area to use. I think this is a *most valuable sugyestion*, and the credit for it belongs to Mr. Henry L. Doherty.

The thickness of the walls of the flues also affects the heat transmission. Mr. Bredel, in his paper before the Western Gas Association in 1892, publishes a diagram showing the number of B. T. U. transmitted through firebrick walls of different thicknesses per 1,000 square feet of surface for various differences of temperature in degrees F. between the inside and outside. This is a very valuable diagram, and shows the superiority of thin walls for this purpose.

Heat Losses During Operation and Their Effect on Bench Design.—In regard to recuperation it is surely true that, for maximum economy, this should be carried to its ultimatum, although this is contrary to general belief. It may even be necessary to use supplementary iron recuperators, but such practice points strongly in favor of isolated generators and producer gas firing, and not to the present constructions.

Concerning radiation, and in fact all losses, it is unnecessary for me to go into figures, as Mr. Bredel in the above mentioned paper has calculated them, and any one interested can refer to same. I might suggest, however, that hollow tile be used in bench construction, as the air is a most excellent non-conductor of heat. Likewise the retort doors and the mouthpieces could be asbestos lined, and the same covered with a thin iron sheeting inside to hold it in place and prevent injury to it. Also, some heat could be saved if automatic stack dampers were provided which would close whenever the furnace doors were opened. All these would tend to increase the life of the bench.

In regard to the shape of the retorts we have, perhaps unconsciously, hit upon the best possible cross section, viz.: The dome shape. Any one can readily see that the reflecting properties of the inner and upper surface of that shape are excellent. There is at present no visible improvement that can be effected in this particular.

Finally, I wish to say that I have endeavored to cover the principal points of bench construction and operation in this paper. Owing to lack of time it has been written in a hurried and somewhat disjointed manner, particularly in respect to the heat reactions. I had hoped to be able to show the calculation when using the mean specific heat coefficients as given in Mr. Bredel's diagram, but must defer this until some future time.

Discussion.

The President—I am sure we all appreciate the immense amount of work done by Mr. Baehr in compiling this valuable paper. In connection with it he refers to Mr. Bredel, and as Mr. Bredel has honored us with his presence, we should all be very glad to hear a few words from him in this connection. (Applause.)

Mr. Bredel—I think Mr. Baehr went into it fully and there is nothing more to say about it. I do not think there is any discussion possible. Mr. Doherty explained it fully as he went along.

The President—Mr. Doherty, have you anything further you should like to bring out in connection with this paper?

Mr. Doherty—I am very much interested in this work, and as Mr. Baehr is not present I would be very glad to take his place in answering any questions or attempting to furnish any further information should it be desired. I will stand sponsor for his paper.

The President—Any questions anyone would like to ask Mr. Doherty? Mr. Miller, we would like to hear some suggestions from you.

Mr. W. A. Miller—Mr. President, I would like to ask Mr. Doherty how frequently he is able to make these tests of flue gases in each bench?

Mr. Doherty—Mr. President, I would prefer to answer all these questions together. I will take the close of the discussion.

The President—Gentlemen, are there any other questions?

Mr. Doherty—I am sorry a paper like this does not bring out more discusssion because I really think it is one that will live in gas literature. I think it will be a text paper for a long time to come. If some of the conclusions Mr. Beahr suggests here are not correct it will start a controversy which will result in clearing us up on these particular points. He touches upon some things that I do not think have been touched upon before by any author who has treated this subject. The attempt was to make this a popular paper, one that would be useful to every man whether he had a technical education or not. It is almost impossible to touch upon some of the details of furnace work and yet do it in a popular way. None of the mathematics contained in this matter (in fact I do not think there are any mathematics in this paper—it is simply arithmetic) are hard to follow if anybody cares to do so. Mr. Beahr has perhaps left himself open to criticism on one or two points. This work will go on in the same way it is progressing now during the ensuing year, so that additional points may be brought up in the near future. Mr. Miller wants to know how often we find it necessary to analyze our flue gases? When we started to improve our furnace results we found it necessary to practically keep two men on it constantly. Now we simply find it necessary to have a man go around each morning and see that the water is properly regulated. We have no periodical time for analyzing the flue gases. As soon as the bench commences to take a little more coke than it has been taking, or than it did take when the operator finished putting it in shape, then we go after the bench again, but we do not pretend to do it regularly because we can tell about how much coke it is taking. If there is any tendency for the coke to burn down we immediately go to work on that bench. I doubt if we are devoting now 30 hours' time a month or the equivalent of one hour's time every day to this work. I doubt if we even devote 10 hours' time per month to our benches. We do not have to, although at first we were devoting probably about 16 hours a day trying to get the benches in good shape. Our fuel conditions are so different in Denver that for me to state the amount of coke required to burn off a ton of coal would not mean anything so far as other localities are concerned where these peculiar conditions do not prevail. By careful furnace work we have succeeded in cutting down our consumption of coke per bench per day fully 25 per cent. So you see the work we have put on it has paid for itself already, and it will keep on paying for all time to come.

Mr. J. W. R. Cline—You operate how many benches, Mr. Doherty?

Mr. Doherty—We operate 20 benches of 6's.

Mr. Lynn—Do you weigh the coke you use in your furnace so as to keep track of the amount of coke in determining whether the furnace is working properly? Is every pound of coke weighed that goes into the furnace, or has it been weighed? You say that you calculate a saving of 25 per cent. and I would like to know how you arrive at that result.

Mr. Doherty—We do not weigh all of the coke. Once in a while we weigh the coke hot without adding any water, and in that way determine the amount of coke produced from a ton of coal, and then we constantly check up on our coke bill to tell how much of that we are getting. At periodical intervals we weigh the coke charged up to our benches. Instead of drawing it directly into the benches we draw it into a barrel and weigh it, but the difference is so great that when I say 25 per cent. I know that I am within all reasonable limits. It easily shows up in commercial results. The difference is so great I am sure my statement of 25 per cent., is a conservative statement so far as the results are concerned. We might be wrong on 1 or 2 per cent., but I know that we are way above 20.

Mr. Lynn.—That is what a gas man would want to know; the results so far as the commercial end of it is concerned.

Mr. Doherty—We can tell the difference by the cash in the drawer.

Mr. Bredel—The only thing that I think in this paper is wrong is the statement as to the low temperature in the conbustion chamber, and it can possibly be explained by the large percentage of ash. He gives only 2,470° F. Now from the experience I have had from my benches I would say that the temperature of the combustion chamber is more than that. I have melted two millimeter platinum wires more than once to my sorrow, so I think the temperature must be far above the amount stated by Mr. Baehr. I know that it is above the melting point of platinum.

Mr. Doherty—What temperature do you figure you have then above 3,400° F.?

Mr. Bredel—I stated in a paper published some time ago exactly how much the temperature was, but I have not got the data with me. I did not know that this subject was going to be brought up, otherwise I would have prepared for it. I know, however, the temperature is stated too low in the paper because it takes nearly 2,000° F. to carbonize the coal, and I know that the degree of temperature is above the melting point of platinum.

Mr. Doherty—What shall we use then?

Mr. Bredel—Seamon's "selen pyrometer."

Mr. Doherty—That is an air pyrometer?

Mr. Bredel—No; it depends upon the resistance of selen, and the temperature is measured directly by the radiation. I know the temperature is above the melting point of platinum, because I wired two tubes to-

gether, the wiring was being done with two millimeter platinum wires, and I got part of it out and part of it stayed in the furnace, but I could see where it was melted all right.

Mr. Doherty—Mr. Bredel's statement would indicate that the temperature in the furnace was above 3,500° F. Now we have inserted this pyrometer in our furnace with impunity. I cannot see exactly why the excessive amount of ash would affect the flame temperature. It should not. We are burning carbon, and the only bad effect that the ash would have would be that it would reduce the flame temperature to the extent of its thermal capacity, which, of course, is very low. I agree with Mr, Bredel in his statement that some of these measurements seem to be wrong. I have always figured the temperature of the combustion chamber at about 2,500° up to 3,000°. I have never figured them as high as Mr. Bredel, and as a rule I have assumed that the temperature, at the top of the recuperators, was about 2,000°. Mr. Baehr, I see, gives it as 1,475. I think that would indicate that it is wrong. In this paper, however, Mr. Baehr has simply given what he had at the time. We had just gotten this pyrometer, and he hurried up to make some measurements in order that he might incorporate the results in the paper. I would like to have Mr. Bredel tell us more about this Seamon pyrometer. I do not understand what material was used for the portion that went into the furnace.

Mr. Bredel—It doesn't go into the furnace. It is outside the furnace.

Mr. Doherty—You place it outside the furnace and the resistance of this material changes, then you measure the resistance by placing it against the Wheatstone bridge.

Mr. Bredel—Yes; the resistance changes according to the quality of the light admitted. The large amount of water vapor that has to be admitted on account of the ash decreases with the flame temperature or tends to keep your flame temperature down. The water vapor would decrease the flame temperature necessarily to a very considerable extent.

Mr. Doherty—Mr. Bredel says we would need more water vapor because we had more ash; but I do not think that would necessarily follow, because what we have to do is to keep the flame temperature down below the fluxing point of ash. I do not think the quantity of ash would necessarily result in a lower temperature. All we have to do is to keep the temperature—whether there is much or little—simply below the fluxing point of the ash. Mr. Bredel has referred to this Seamon pyrometer and, as I understand, it measures the radiant heat?

Mr. Bredel—Yes.

Mr. Doherty.—Recently in a discussion we had on lamp filaments and the efficiency of the Nernst lamp, I had occasion to look it up to see whether the primary law upon which it has been based was correct or not. And that is that all solid bodies would have the same temperature if giving out the same amount of radiant energy. I can find that law quoted and quoted and quoted; but as far as I can ascertain the law has never been determined, and I do not believe it is possible to determine it. I believe the substance heated would affect the amount of radiant energy you would get. One substance at one temperature would give off a different amount of radiant energy from another substance at the same temperature. In fact we know in the case of carbon lamp filaments that the surface of the filament has a great deal to do with its light giving properties. If it is bright and smooth and has a metallic finish it is much more efficient than when dark and rough and without metallic finish, and the pyrometrical tests must be based upon the assumption that the amount of radiant energy will always bear an exact relation to the total energy. Then it is easy for me to conceive how you might get a focus effect as a result of radiant energy. I figured once on building a dome furnace—before electrical furnaces were available—to get a higher temperature out of the combustion. The plan which had occurred to my mind was that the dome should be so shaped that it would reflect all of my heat to a point in the bottom of the furnace. And if you could get anything like a focusing effect with this pyrometrical test it would give you a wrong reading. Your rays must be paralleled. If there is any tendency to converge or to focus the reading would be affected.

Mr. Butterworth—On pages 71 and 72 Mr. Baehr calls attention to the desirability of having wide furnaces and a large grate area. In that connection it might be interesting to state that at Denver we have 20 benches, 10 of which have wide furnaces and 10 of which have narrow ones, the narrow furnaces being but a little more than one-half as wide as the wider furnaces. With the same character of coal exactly we have to clinker the narrow furnaces 4 or 5 times as often as we do the wider ones.

The President—That is a very valuable point I am sure. Any further suggestions, questions or discussion? If not we will pass on to other business.

On motion of Mr. Persons a vote of thanks was extended to Mr. Baehr for the preparation of his valuable paper. The motion also extended a vote of thanks to Mr. Doherty for reading the paper and for the suggestions made by him in the discussion thereof.

A Brace of Invitations.

The President then extended to the members of the Association a cordial invitation on behalf of the Franklin Gas Appliance Exchange, with headquarters on Plum street, to visit the Exchange for the purpose of inspecting the latest gas appliances.

The President also announced that the members were cordially invited by the Cincinnati Gas and Electric Company to be its guests that night at the Grand Opera House, to witness Julia Marlowe's Company in the "Cavalier."

The President—As we have some time before the noon adjournment I suggest that we now take up the paper, by Mr. F.W. Stone, of Ashtabula, O., on the subject of

NATURAL GAS AS A FACTOR IN THE ARTIFICIAL GAS BUSINESS.

That natural gas is a factor in the artificial gas business in some sections of this country, especially in Ohio, must be evident even to the most casual observer. At the present time in Ohio, over 50 per cent. of the artificial gas plants are either having natural gas as a competitor, or else are being changed to natural gas plants. In some cases the competition of natural gas has been so strong that the artificial gas plants have been abandoned.

When I say that over 50 per cent. of the artificial gas plants in Ohio consider natural gas a very potent factor in their business, I do not tell all of the truth, for this 50 per cent. includes almost all of the larger cities and towns, the writer being only able to think of 6 cities of over 10,000 inhabitants in this State where natural gas is not used.

It also must seem that natural gas has been somewhat of a factor in fixing the prices of artificial gas, as it would appear to be more than a coincidence that in the regions where natural gas is the most used, the average price of artificial gas is the lowest.

There are those of us who were in the artificial gas business when threatened by natural gas competition and have realized how useless it was to fight. Welsbach lamps are cheap and natural gas will give as good a light in one as artificial gas, and this with natural gas at 25 cents and artificial gas at $1, at less than one-fourth the cost. For cooking and heating purposes natural gas has the same relative advantages. In all these ways natural gas has apparently been a factor adverse to the artificial gas business, but this is only one side of the case.

I believe that the use of natural gas has aided the artificial gas business by helping the sale of fuel gas appliances. People in towns not favored by natural gas heard of its use; gas was gas to them, one kind the same as another. They wanted it and made a demand for it. The manager of an artificial gas plant said to himself, if there were appliances adopted for its use I could sell gas for fuel just as well as the other fellow. The appliances were made and the demand of the public met. The natural gas business has also undoubtedly taught the artificial gas manager the value of selling a large quantity of gas at a low price. We have also learned from our natural gas brethren the usefulness of distributing gas through high pressure lines to the point where the demand is the greatest and there reducing the pressure to meet the local needs. But it is in the future that natnral gas will play the most important part in the development of the artificial gas business. The manager of every artificial gas plant that is having natural gas competition, or has changed over from artificial gas to natural gas, is thinking of the time when natural gas shall be exhausted. That the public generally believe that within a few years this may be the case is evidenced by the fact that, in almost all the franchises that have recently been granted, there is a clause allowing the company to supply artificial fuel gas, should the supply of natural gas become exhausted.

Think of the plant and the demand then. A town of 10,000 inhabitants thoroughly piped for natural gas should have about 25 miles of mains, about 2,500 customers and will sell about 350 million feet of gas a year. The daily output, however, will vary from over two million feet a day in the winter time to 100,000 feet on a summer day. In fact on two consecutive days in the winter the output may vary one million feet.

Of course, if he were to change to artificial gas he would not keep all of this trade, yet if by some unknown hook or crook he could sell an artificial gas containing about 650 heat units for 50 cents per 1,000 cubic feet, he would probably keep about one-third of it, and the part he would lose would be that which had caused the greatest variation in his output.

From what I know of the fuel business I have no doubt but that, under the conditions stated and with proper appliances, all of the cooking, all of the office heating and a fair portion of the heating of dwellings could be done with artificial gas. There has been current in the land an idea that there was a great difference between the sale and distribution of natural and artificial gas, but I cannot see that there should be any great difference. Of course you distribute natural gas at a higher pressure and must be prepared to meet greater variations in output. In the beginning of the natural gas business there were no devices by which it could be used successfully for light, and its low price made that field undesired by the manager as there was no money in it. On the other hand there were no appliances by which artificial gas could be used as fuel. Both conditions have been met and the price of natural gas is going up and that of artificial gas going down. It will not be long until the managers of both artificial and natural gas plants will use the same methods for getting and retaining business. I predict, and I guess that I have as much right to prophesy as anyone, spurred on by the demand for fuel gas, gas engineers will, in the near future, find a way to make gas cheaply in large quantities. That the gas works of the future will be built more with a view to the product of a fuel gas rather than a gas for light. That it will be built to meet a varying demand. That the gas will be pumped through high pressure lines to various points of distribution where the pressure will be reduced.

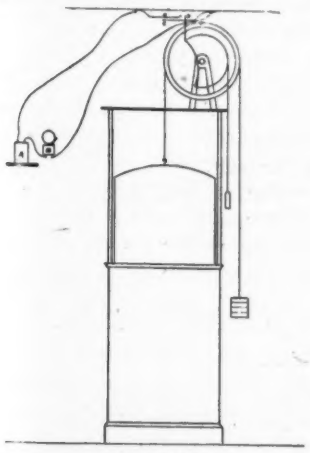
[To be Continued.]

Wrinkle Department: Second Annual Meeting, Wisconsin Gas Association.

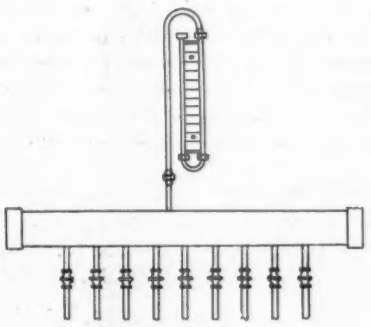
Edited by Mr. R. C. Cornish, Racine, Wis.

The Editor has not been as fortunate this year as he was last in securing material. However, a few have responded with some very good wrinkles, which I will present to you.

No. 1 is offered by Mr. B. F. Ellison, of West Superior, Wis. It is an electrical arrangement to attach to an ordinary meter prover to give an alarm when it is time for the operator to make his readings. This enables the operator to work at something else between times without endangering his readings. In the sketch *A* is the battery; *B* bell. *CC* contact points on springs of copper; *D* is copper bar attached to prover, and can be adjusted to make contact at any desired point.



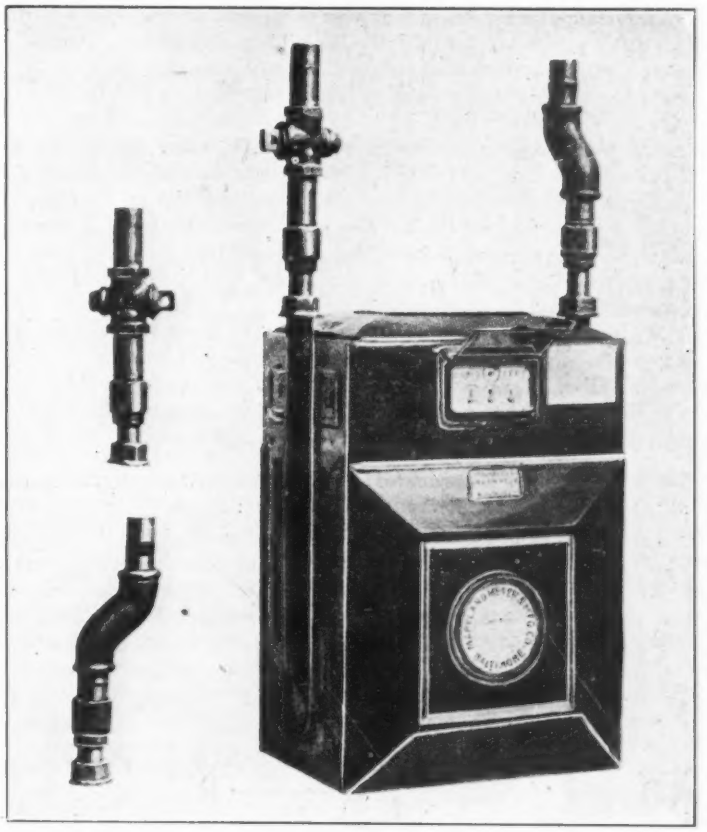
Wrinkle No. 1.



Wrinkle No. 2.

No. 2 is offered by Mr. H. H. Hyde, of Racine. It is a cheap and simple way of connecting up several pressure pipes to one gauge. A piece of 1¼-inch pipe of desired length is capped up on ends and tapped on one side for gauge, and on other side for the pressure pipes, with ¼-inch pipe tap. Each pressure pipe is provided with a stopcock to shut it off.

Nos. 3 and 4 are offered by Mr. R. B. Brown, of Milwaukee. No. 3 is an iron pipe meter connection, and No. 4 an emergency stop box, to be used in case of fire. Mr. Brown gives the following explanation of his wrinkles: The iron pipe meter connection we are using successfully and consider better on the following grounds: It is no more expensive than a moderately long lead connection, and is safer—we have had both "Eureka" and soldered connections fall apart while in use. When once set it is free from leaks, nor can the gas be throttled by careless bending, as with the lead tubing. The connections need not be removed when the meter is taken out, and the temptation to steal them is much less than with the old style.

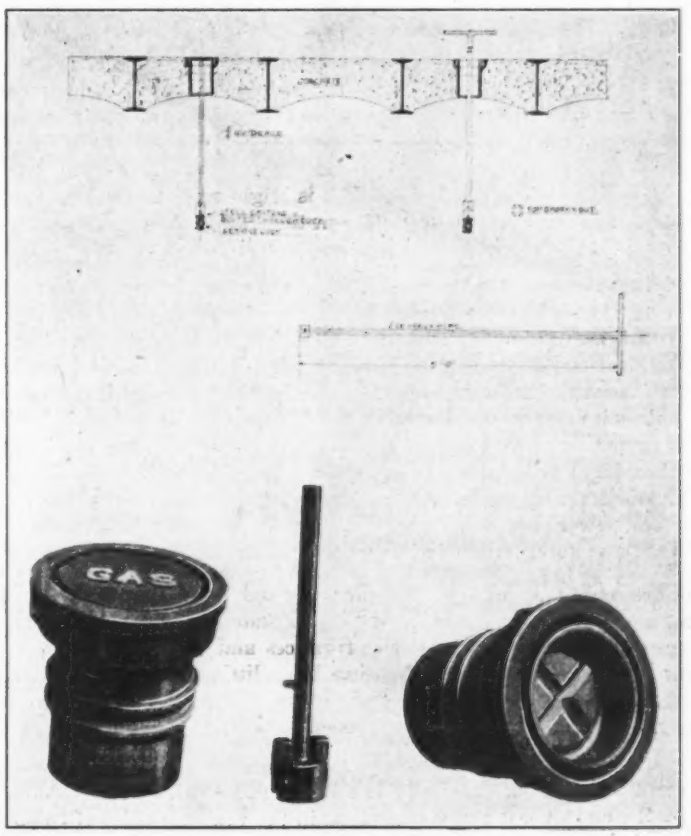


Wrinkle No. 3.

You will note that we use a reducing coupling at the meter swivel on the 5-light connections. By simply removing this reducing coupling and replacing it with a straight coupling and a 10-light swivel, which latter the wagon men always carry with them, any 5-light connection can be changed to accommodate a 10-light meter, and as these two sizes cover 95 per cent. of our work, the convenience of being able to interchange as above will be appreciated by anyone familiar with the work.

The use of the iron pipe connection practically eliminates that form of complaint work designated "leak at connection," of which we have so many on the old style of connections.

The "hollow sidewalk box" was gotten up to cover the fire depart-



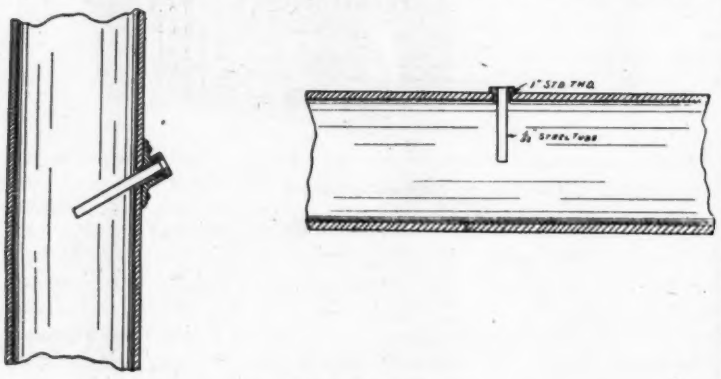
Wrinkle No. 4.

ment's demand for an emergency stop to be used in case of accident or fire. Such a box must fulfill the following conditions: It must be cheap; that is, there cannot be much, if any, machine work on it. It must be absolutely water tight, as many people store perishable goods under the sidewalks in these days. It must not be possible for any meddlesome person to so tamper with the box as to either leave the cover off or to leave it in anything but water tight condition. It must be possible to instantly open the box in any weather without special tools, and after having opened the box the arrangement for turning the stop-cock should be extremely simple, and so placed that the fire department men, under the most unfavorable conditions, will have no difficulty in reaching the head of the cock with the key.

The use of this box, as will be readily noted from the drawing and photograph, means the smashing of the plug and replacing it with a new one, all of which, including the man's time, costs about 50 cents. As these stops are not used except in case of emergency or fire, the expense attendant upon such replacement is merely nominal.

No. 5 is offered by Mr. James H. Walker, of Milwaukee. It is a thermal tube, described by Mr. Walker as follows:

"The idea is to provide a convenient way of ascertaining the temperature of gas, water, steam, etc., passing through horizontal or perpendicular pipes without having permanent thermometers placed in exposed places, where they are liable to be broken. The sketches will explain themselves. The tubes are of thin steel screwed into bushings



Wrinkle No. 5.

which are screwed into pipes, when pipes are horizontal, or into a special flange when pipes are perpendicular."

The Editor has used a homemade arrangement on his ammonia apparatus, made by capping up a ¼-inch pipe and screwing it into a 1-inch bushing. The pipe in this case was filled with glycerine and an ordi nary glass thermometer used. I noticed at Grand Rapids, Michigan, they were using ordinary dairy thermometers, which can be bought by the dozen for about $2.50.

How to Become an Electrical Engineer.

Writing on this topic, Prof. Parr, of London, England, says: On leaving school, between 16 and 17, a suitable college should be chosen, and there the prescribed course of, usually 3 years, but sometimes only 2 years, should be entered upon with a view to taking either the degree or certificate of the university or college. The former calls for a higher theoretical standard than the latter usually, but the practical work is much the same in the two cases. In using the term practical work in a college it must be understood that this relates to the action, behavior and properties of well-known appliances, together with the application of theoretical principles, and not to such practical work as is obtained in manufacturing works or in the supply of electrical energy for lighting and power purposes.

It is, therefore, extremely important that a youth, on leaving college, after having obtained his degree or certificate, should be apprenticed in some prominent electrical manufacturing works for 12 to 18 months, where he can learn the actual methods of manufacturing electrical machinery and appliances. It would, in addition, be greatly in his favor in after life, if he could spend a further 12 or 18 months in some engine works in order to learn turning, fitting, etc., connected with the manufacture of engines, as this will stand him in great need if he ever becomes a central station engineer. Though the youth will have had a certain amount of drawing office experience at college, he should, if possible, endeavor to spend some time in the drawing office of either or both of the works above mentioned, so as to obtain an insight into methods employed in practice. The theoretical training can only be obtained at college with any degree of satisfaction, while only a small amount of the practical taught at college can be learned at works, and *vice versa*.

Further, it should be remembered that practical training without college training, and *vice versa*, is of very little use. In order that a youth of given ability may have the best facility for attaining eminence in after years, such a course as the above should be gone in for. To those who are unable to afford the expense which this entails, the writer would recommend either the engine or manufacturing works training only—whichever the youth has an inclination for and prospects of advancement in.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

MR. F. B. ALDRICH, General Manager of the Pottsville (Pa.) Gas Company, informs us that we were in error in saying that Mr. James R. Bowen had been appointed Superintendent of the Company. The new appaintee is Mr. O. W. Crawshaw.

MR. R. C. CORNISH has resigned the position of Superintendent of Works of the Racine (Wis.) Gas Light Company, to accept a responsible place in the service of the Milwaukee (Wis.) Gas Light Company. His successor at Racine is Mr. W. A. Luenberger.

MR. IRA C. COVERT has resigned the Superintendency of the illuminating division of the business of the Newark (O.) Gas Light and Coke Company, to take engineering charge of the properties of the Paducah (Ky.) Gas and Electric Company, which place he assumes the 15th inst.

AT the special meeting of the shareholders in the Fitchburg (Mass.) Gas and Electric Light Company, Mr. Hobart I. Wallace was elected President, vice his father, the late Mr. Rodney Wallace, and Senator George R. Wallace was elected to the vacancy on the Board of Directors. The following memorial to Mr. Rodney Wallace was adopted by the shareholders: "Since April 27, 1864, this Company has had but one President, the man whose loss we mourn to-day. For 38 years in succession Rodney Wallace, the second President since the formation of the Fitchburg Gas Company in 1853, whs elected President. None of the Board of Directors at the time of his first election are living, and he survived the last by many years. From a small beginning the Company has grown to its present proportions under his direct oversight and watchfulness. Although favored with an excellent Treasurer, his brain directed and controlled each step. The deep respect and entire confidence in which he was held, made perfect unity in the management. For all that he did to make this Company a success he never would accept a salary for the services he rendered so ably and well. He was always ready with his careful consideration and safe counsel in which we trusted implicity and with reason. That he has taken his seat with us for the last time is hard to realize. All we can do now is simply to record our testimony to the solid worth and loyalty of our honored President and dear friend."

MR. CHARLES E. DOLE has resigned the Superintendency of the Bangor (Me.) Gas Company.

THE South Jersey Gas, Electric and Traction Company has purchased the propertles of the Bristol (Pa.) Gas Company. The new proprietors propose to extend the Company's distributing system to the adjoining districts of Tullytown, Yardley and Morrisville.

MR. JAMES HAINES, of Philadelphia, succeeds Col. E. G. Pratt as Resident Manager of the properties of the Capital City Gas Company, Des Moines, Ia.

LAST year the output of the Galesburg (Ills.) Gas and Electric Company amounted to 2,718 cubic feet per capita of the population.

MR. EUGENE W. LEE has been appointed to a responsible position in the service of the Escanaba (Mich.) city lighting plant.

THE Ogden Gas Company, of Chicago, has been adding to its real estate possessions through the purchase of a plot on the west side of Hawthorne avenue, about 300 feet north of North avenue. The plot adjoins the Company's present site.

MR. FRANK H. HAMBLETON has resigned the position of Engineer-in-Chief to the Consolidated Gas Compaay, of Baltimore, Md. His successor is Mr. George Beadenkopf, who acted as Assistant Engineer to

the Company for several years. Mr. Hambleton will, however, serve the Company as its Consulting Engineer.

A BILL was recently signed by the Governor of California which provides that "It shall be the duty of all persons and corporations engaged in supplying gas and electricity for domestic lights and heat and water for domestic purposes, to provide and maintain on the premises of each consumer, without cost to such consumer, the most improved and effective meters and appliances for measuring, regulating and controlling the delivery of gas, electricity and water furnished to consumers." It is stipulated that if the Company refuses to put in the meter upon demand, the consumer shall not be obliged to pay for the water, gas or electricity used by him during the failure of the Company to provide the necessary registering apparatus, etc.

MR. ISAAC C. GILMOR, a Director in the Consumers Gas Company, of Toronto, Ont., since 1860, died at his home in Toronto, the afternoon of March 31st. He was in his 91st year, having been born in Three Rivers, Canada, August 12, 1812.

THE offices of the Danbury and Bethel (Conn.) Gas and Electric Light Company will be removed to handsome and commodious quarters in the Library building, as soon as the necessary changes in the floor plans, etc., can be completed.

THE Ohio Fuel Supply Company has purchased the plant and franchises of the Federal Natural Gas Company, which concern has been operating in Columbus, O., for some time.

THE City Gas Company, of Norfolk, Va., has filed with the Interstate Commerce Commission a petition against the Baltimore and Ohio Railroad, the prayer alleging excessive and unreasonable rates for transportation charges, and that defendant is receiving more for transporting coal to the plaintiff's gas plant than it demands from others for a similar service.

A CORRESPONDENT informs us that at a special meeting of the Directors in the New Haven (Conn.) Gas Light Company, Mr. Frederick F. Brewster was elected to the vacancy on the Board caused by the death of ex-Governor Charles R. Ingersoll.

MR. BURDETTE BOWEN, of Detroit, Mich., has purchased a controlling interest in the Marshall (Mich.) Light Company, and will assume the practical direction thereof.

IT is said that the projected plant for Beaver Dam, Wis., will be constructed this summer. We doubt it.

THE Merchants Gas Company, of Norwich, N Y., is now owned by the Norwich Gas and Electric Company.

THE proprietors of the Maysville (Ky.) Gas Company have announced the following selling rate schedule, the same to take effect on all gas consumed from the 1st inst.: Under 2,000 cubic feet per month, $1.50 per 1,000; over 2,000 cubic feet and under 3,000 cubic feet, $1.25; 3,000 cubic feet and over, $1.

THE Steelton (Pa.) Home Gas Company proposes to extend its mains this summer to the outlying districts of New Cumberland, Riverton, White Hill and Wormleysburg.

MR. EWALD HAASE, who had been Assistant Secretary of the Milwaukee (Wis.) Gas Light Company, and who had it was said agreed to follow Mr. E. G. Cowdery in his hegira to the Laclede Company, of St. Louis, Mo., has rescinded his plans. He will remain with the Milwaukee Company as its Secretary, succeeding Mr. Sheldon J. Glass, who, as was said in the JOURNAL, has been appointed Secretary of the American Light and Traction Company.

THE Quincy (Ills.) Gas and Electric Company has been purchased by the Tilford-Lynn syndicate of New York.

THE Bay City (Mich.) *News* is our authority for the statement that the Company's franchise has been extended for a period of 30 years, and that under the agreement the selling rate is to be put at $1 per 1,000 cubic feet.

THE manufacturing plant of the Windsor (Can.) Company is to be doubled.

THE proceeds from the sale of the new issue of stock by the Citizens Gas Company of Jacksonville, Fla., will go to paying for plant betterment. The increase amounts to $25,000.

A RECENT issue of the Portland (Ore.) *Journal* said: "The men in the employ of the works force of the Portland Gas Company have been granted an 8-hour day, at the rate of wages heretofore paid them for a 12-hour shift. The concession was voluntary on the part of the Company.

A CORRESPONDENT in Poughkeepsie, N. Y., forwards the following clipping: "It is not at all improbable that the Poughkeepsie Light, Heat and Power Company will supply gas in the near future at $1.30 per 1,000 cubic feet for all purposes, the one price to be charged for gas for both illuminating and heating purposes. It is understood that negotiations were opened recently when the Company made a proposition to Mayor Hine offering to supply gas at the price above mentioned. Mayor Hine will submit the proposition to the Common Council at its next regular meeting. It is known that the Directors of the Poughkeepsie Light Heat and Power Company were getting ready to make a reduction in the price of gas and had almost had the matter consummated when the resolution calling for dollar gas was presented to the Common Council. A Director of the Company said: 'We do not want to be unfair with the people of Poughkeepsie. We want to earn their good will and all we ask is a fair return for the investment we have made here.'"

ON March 31st the Committee on Public Lighting, Massachusetts Legislature, was in session on the annual report of the Board of Gas and Electric Light Commissioners, the hearing being given up to one phase only of the report, a single recommendation that that there be a consolidation of the Boston Gas Companies. Hon. F. E. Barker, Chairman of the Board, addressed the committee at length, saying the present situation in Boston was a confusing one. The prevailing belief is that there is only one Company here, while the fact is that all the Companies ever operating here are at present doing business under their original charters. He sketched the history of the development of the Companies up to the time in 1893 when the Boston authorities permitted the Brookline Gas Light Company to come into the field for the purpose of remedying a supposed grievance. The Brookline Company not only laid pipes in Boston proper, but in Roxbury, Dorchester and South Boston. There is not a political economist in the country, he said, but will tell you that such a conflict as resulted cannot continue. If undertaken it will be temporary only, and that a consolidation must result in one way or another. General Schaff said the Companies were consolidated already and cannot be consolidated any more. The trouble is that the public, which is virtually a partner in a busines of from $20,000,000 to $30,000,000, is not getting its share of the benefits. The business should be definitely supervised. F. E. Snow, representing the Companies, said they had no disposition to escape supervision. Henry D. Yeaton then addressed the Committee protesting against the consolidation as against the public interest, as it might make one Company with a capital of $50,000,000. He thought it would be unfortunate to take any such legislative action at the present time, when litigation is in progress concerning the legality of the operations of the association holding the stock of the Companies. In part he said: "I represent a client who is the owner of securities based on the stock of four of the Boston Gas Companies. I have not seen the bill recommended by the Commission or any bill in accordance with the report of the Commission for the consolidation of the Boston Gas Companies, in their current report. Therefore, I am not prepared to state at this time whether I shall oppose any bill presented or not. I do not believe it possible, however, for any bill to be drawn, which, to use the words of the Commission, will consolidate the Gas Companies in Boston in form and in fact into a single responsible corporation, readily amenable to the general laws of the commonwealth, without first revoking the charters of the present Companies or in other ways wiping them out of existence, or, second, creating in addition a new one, which will further complicate the situation. The Commission comes here with a recommendation, as it probably believes, in the interest of the public. In order to accomplish that, whatever scheme is presented must contemplate a reduction in the price of gas, better quality and better service. If all this is not obtained, then the scheme has no standing before this committee and Legislature. It has been rumored for some time that a bill has been prepared by Mr. Robert Windsor, of Kidder, Peabody & Co., in conference with Colonel Wm. A. Gaston and his law firm, in the interest of the new $50,000,000 Massachusetts Gas Companies, a voluntary association, and that that bill was to be presented by the gas commission as its bill in accordance with recommendation in its current report. It will be plain to you, gentlemen, that any bill in the interest of this association will not provide for a reduction in the price of gas in Boston. It will also be plain to you that any bill in the interest of these gentlemen providing for the capital stock of a new corporation will very largely exceed the capital of the corporations now supplying gas to the people of Boston, to wit, $9,300,000. The object, I think you will be able to determine, is twofold, first, for a capitalization sufficient to pay a good dividend, say 4 or 5 per cent. on this $50,000,000 association, and, second, to use the great power of the Commonwealth to confiscate the property to shield these gentlemen from the probable results of the suit now pending before the full bench of the Supreme Judicial Court wherein my client is one of the plaintiffs."

THE AMERICAN GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,
PROPRIETORS.

MONDAY, APRIL 13, 1903

The Market for Gas Securities.

The market for city gas shares in the week was quite like that which prevailed since the Col. Robert Grier Monroe crusade, in behalf of the starting of an electric lighting plant on municipal account. Quotations have been nominally on the low side, but actual transactions were almost at the "vanishing point," which, of course, is the end of perspective. The municipalists, acorns and Hearsts, have undoubtedly met with discomforture over their suddenly conceived project on municipal account, for their composite efforts have been even unable to cause a reporting of the scheme, from either the Senate or Assembly Committee that had been digesting it. Good-bye, then, to their ill timed, peculiar looking effort. Consolidated closed yesterday (Thursday) at 206 to 206¼. Our advice is to buy.

Brooklyn Union sold at 210, and in view of the almost certain near resumption of dickering for a trade of its properties to the New York gas interests, we have no hesitation in saying that before May is ended the stock will sell at a record price for it—which is certainly on its face a bold prophecy. Peoples, of Chicago, remains steady, despite the efforts of a powerful financial lot to "pound" it. Keep your eyes on Detroit gas, in which one of the usual pyrotechnic displays of the people in interest will shortly be made. The Boston situation is taking on additional complications, wherefore wise men are paying no attention to any further "new" dealing in it. Washington (D. C.) gas will, so its friends say, soar to 450 by July.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

16 WALL STREET, NEW YORK CITY.

APRIL 13.

☞All communications will receive particular attention.

☞The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$78,177,000	100	206	206½
Central Union, Bonds, 5's.	3,000,000	1,000	109	111
Equitable Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	118	120
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	310	325
Municipal Bonds	750,000	..	..	..
New Amsterdam Gas Co.. Bonds, 5's	11,000,000	1,000	108½	109
Northern Union, Bonds, 5's.	1,250,000	1,000	104	107
New York and East River Bonds 1st 5's	3,500,000	1,000	112	113
" 1st Con. 5's	1,500,000	..	109	111
Standard	5,000,000	100	132½	140
Preferred	5,000,000	100	152	160
Bonds, 1st Mortgage, 5's	1,500,000	1,000	115½	118
Yonkers	299,650	500	130	..
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	209	215
" " Bonds (5's)	15 000,000	1,000	119	119½
Bay State	50,000,000	50	⅜	½
" Income Bonds	2,000,000	1,000	..	75
Binghamton Gas Works	450,000	100	28	30
" 1st Mtg. 5's	509,000	1,000	93	96
Boston United Gas Co.— 1st Series S. F. Trust	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47½	50
Buffalo City Gas Co.	5,500,000	100	7	10
" " Bonds, 5's	5,250,000	1,000	73	76
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Central San Francisco	900,000	..	106	108
Chicago Gas Co. Guaranteed Gold Bonds	7,650,000	1,000	104	104¼
Cincinnati Gas & Elec. Co..	29,500,000	100	97½	98
Columbus (O.) Gas Co., 1st Mortgage Bonds	1,500,000	1,000	101	101½
Columbus (O.) Gas Lt. & Heating Co	1,682,780	100	88¼	89¼
Preferred	3,026,500	100	107½	109
Consumers Jersey City Bonds	600,000	1,000	103	106
Consumers, Toronto	1,700,000	50	218	225
Consolidated, Baltimore	11,000,000	100	70¼	70½
Mortgage, 6's	3,600,000	..	..	118
Chesapeake, 1st 6's.	1,000,000	..	..	..
Equitable, 1st 6's.	910,000	..	..	..
Consolidated, 1st 5's	1,490 000	..	..	112
Consolidated Gas Co. of N.J.	1,000,000	100	15	17
" Con. Mtg. 5's	880,000	1,000	85	87
Consolidated G. & E. Co.'s. Little Falls, N.Y.	90,000	100	..	100
Bonds	75,000	..	..	100
Detroit City Gas Co.	4,825,500	50	..	89
" Prior Lien 5's	5,603,000	1,000	99¼	100
Detroit Gas Co., 5's	981,000	1,000	77	79
" Inc. 5's	16,000	100	98½	100
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Essex and Hudson Gas Co.	6,500,000	..	34	38
Fort Wayne	2,000,000	..	..	..
" Bonds	2,000,000	..	55	..
Grand Rapids Gas Lt. Co. 1st Mtg. 5's	1,225,000	1,000	104½	105
Hartford	750,000	25	245	265
Hudson County Gas Co., of New Jersey	10,500,000	..	25	..
" Bonds, 5's	10,500,000	..	101	103
Indianapolis	2,000,000	..	80	85
" Bonds, 6's	2,650,000	..	105	107
Jackson Gas Co	250,000	50	73	75
" 1st Mtg. 5's	290,000	1,000	101	102½
Kansas City Gas Light Co., of Missouri	5,000,000	100	..	36
Bonds, 1st 5's	3,822,000	1,000	102	104
Laclede, St. Louis	10,000,000	100	97	100
Preferred	2,500,000	100	105	110
Bonds	10,000,000	1,000	109½	110
Lafayette Gas Co., Ind.	1,000,000	100		60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	130	140
Madison Gas & Elec. Co. " 1st Mtg. 6's	350,000	1,000	107½	108½
" 6 per cent. scrip, due 1910	100,000	25	85	87
Montreal, Canada	2,000,000	100	218	184¾
Nashville Gas Lt. Co.	1,000,000	100	110	..
Newark, N. J., Con. Gas Co	6,000,000	..	56	58
Bonds, 6's	4,600,000	..	105	105¾
New Haven	1,000,000	25	300	325
Oakland, Cal.	2,000,000	..	46	47
" Bonds	750,000	..	..	.
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	100	100¾
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	20,100,000	1,000	..	..
2d "	2,500,000	1,000	104	
Rochester Gas & Elec. Co..	2,150,000	50	88	..
Preferred	2,150,000	50	118	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	10,000,000	100	52¾	53
St. Joseph Gas Co. " 1st Mtg. 5's	751,000	1,000	95	96½
St. Paul Gas Light Co.	1,500,000	100	45	47
1st Mortgage 6's.	650,000	1,000	113	116
Extension, 6's	600,000	1,000	112½	115
General Mortgage, 5's.	2,465,000	1,000	92	93
Syracuse, N. Y.	1,975,000	100	42	45
Bonds	2,047,000	1,000	98½	99½
Washington, D. C	2,600,000	20	408¼	411¼
First mortgage 6's	600,000	..	..	..
Western, Milwaukee. Bonds, 5's	4,000,000	..	109½	110
Wilmington, Del.	600,000	50	232	..

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STOCKHOLDERS' MEETING.

OFFICE OF THE UNITED GAS IMPROVEMENT CO.,
N. W. CORNER BROAD AND ARCH STS.,
PHILADELPHIA, PA., February 27, 1903.

The Annual Meeting of the Stockholders of the United Gas Improvement Company will be held at the office of the Company, northwest corner of BROAD AND ARCH STS., PHILADELPHIA, on Monday, May 4, 1903, at 12 o'clock, noon, for the purposes of electing a President and six Directors, to serve for the ensuing year, considering and acting upon the subject of a proposed increase in the capital stock of the Company from 565,000 shares, of the par value of $50 each, to 734,500 shares, of the par value of $50 each, and transacting such other business as may properly come before the meeting.

The stock transfer books will be closed from 3 P.M., April 28, until 9 A.M., May 5th.

By order of the Board of Directors.

1448-8 LEWIS LILLIE, Secretary.

DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO.,
N. W. CORNER BROAD AND ARCH STS.,
PHILADELPHIA, PA., March 11, 1903.

The Directors have this day declared a quarterly dividend of 2 per cent. (one dollar per share), payable April 15th, 1903, to stockholders of record at the close of business, Mar. 31, 1903. Checks will be mailed.

1450-4 LEWIS LILLIE, Treasurer.

MISS LILY HAXWORTH,

Cooking Teacher and Lecturer,

(GOLD MEDALLIST),

Is open for engagements. For terms, etc.,

1441-3m Address 323 QUINCY ST., BROOKLYN, N. Y.

COOKING BY GAS.

MISS RUTH WILKINS,

Lecturess on Cooking by Gas.

Terms and references sent on request. Address,

1453-4 509 N. CHURCH ST., ROCKFORD, ILLS.

POSITION WANTED.

The advertiser has had over 20 years' experience in the gas business, and is now in a responsible position with a large city company. Is capable of managing, but would accept subordinate position until merit is recognized. Would guarantee to increase sales and receipts and reduce expense. Good reasons for desiring a change.

1453-1 Address, "PUSH," care this Journal

Position Wanted

AS MANAGER OF A GAS COMPANY,

By a man thoroughly competent. Am successful in all details of the business, with several years' experience,

1452-tf Address, "G. A.," care this Journal.

Position Wanted

By a party who for the past 12 years has filled a responsible position in one of the largest gas companies in the United States, and is a thorough systematizer and hustler for new business Can furnish satisfactory reasons for desiring to make a change. Best references as to ability and energy as a gas man Address, "AMBITION,"

1453-2 Care this Journal.

POSITION WANTED

AS GAS MAKER,

By an experienced operator. References.

Address, "PHILA.,"

1453-1 Care this Journal.

WANTED,

A Position by a Man 24 Years of Age.

Five years' experience in collecting, gasfitting, meter reading and meter repairing.

Address, "X. Y. Z.,"

1453-1 Care this Journal.

WANTED,

Position as Superintendent of Gas Works.

Fifteen years' experience in manufacturing and distributing departments. Can give good references. Have charge of gas works at present. Address, "F. C.,"

1452-2 Care this Journal.

GASHOLDER WANTED.

We wish to purchase a second-hand gasholder, of a capacity of 50.000 cubic feet. In replying state condition, price, etc.

1452-2 Address, "GASHOLDER," care this Journal.

FOR SALE, CHEAP.

SET OF 4 PURIFIERS.

Six feet by 10 feet 6 inches by 3 feet, with 8-inch connections; wet centerseal and overhead hoists. Address, the

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APPARATUS FOR SALE.

Two Purifying Boxes, 10 feet by 12 feet.
Two Centerseals, 8 inch connection.
Three 3 foot Water Gas Apparatus.

Address, QUEENS BOROUGH GAS AND ELECTRIC CO.,
1453-2 Far Rockaway, L. I.

FOR SALE.

20-horse Power Otto Gas or Gasoline Engine,

In first-class condition. Address,

EARLE H. BUCK,

1452-tf Mgr. Citizens Gas Co., Vincennes, Ind.

FOR SALE.

5-FOOT WATER GAS APPARATUS.

Address, CHARLES G. M. THOMAS,

1449-tf Flushing, N. Y.

APPARATUS FOR SALE.

Four 8 feet by 12 feet by 3 feet purifying boxes, with chain hoist, 8-inch dry centerseal; all valves and connections.

One 5-foot Harris Brothers' station meter, with valves and connections and bye-pass All in good repair.

For particulars and prices, address the

ELMIRA WATER, LIGHT AND RAILROAD COMPANY,

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FOR SALE.

Four Purifying Boxes, 8 feet by 12 feet by 3 feet.
24-Inch Seal in Line, complete with connections.
Hydraulic Lift for Covers and Track.

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Utilize Your Gas Liquor.
NO EXTRA LABOR OR OPERATING EXPENSES.

IMPROVED AMMONIA CONCENTRATOR.

About 100 in use. Write to
STROH & OSIUS, Patentees, or
MICHIGAN AMMONIA WORKS, - Detroit, Mich.

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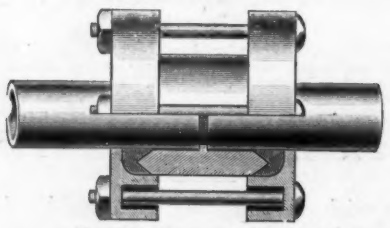
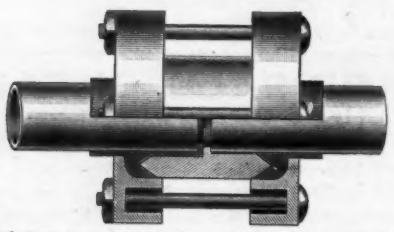
BRADFORD, PENNSYLVANIA, U. S. A.,

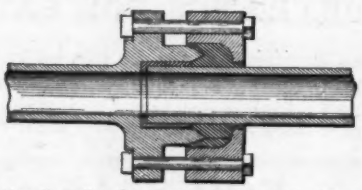
Patentee and Manufacturer of Specialties for Oil and Gas Lines.



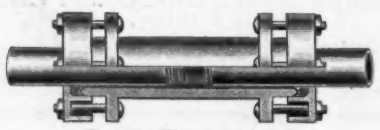
Regular Coupling. Style 1.



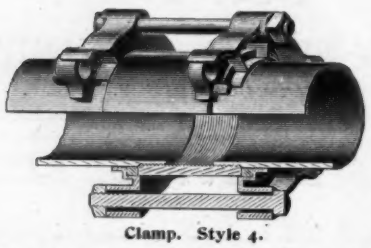
Insulating Coupling for Wrought Iron Pipe. Style 5.



Insulating Coupling for Bell and Spigot Cast Iron Pipe. Style 6.



Regular Sleeve. Style 2.



Clamp. Style 4.

Pipe Couplings, Sleeves, Clamps, Crosses, Tees and Ells.

My Insulating Coupling prevents the destruction of pipe by electrolytic action, in either water or gas lines.

SEND FOR CATALOGUE.

(*Concluded from page 575.*)

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John Cabot, New York City 589

GAS STOVES.
American Meter Co., New York and Philadelphia 585
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Send for Pamphlet on Patents.

1448-tf

Established 1845. Reorganized 1902.

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Manufacturers of the very best quality of Clay Retorts, Blocks, Tiles, Settings and Firebrick of every description.

Also Miners and Shippers of Fireclay, Fire Sand, Ground Brick in Barrels.

WORKS: KREISCHERVILLE, STATEN ISLAND.
OFFICE: 119 E. 23D STREET, NEW YORK CITY.

1903. NEW DETROIT 1903.

Force Draft

ARC GAS LAMP,

With double flash pilot. We save 25 per cent. gas over any other arc and produce more candle power. To light consumption what the gas range is to fuel.

A Handsome Fixture. Always in Order.

We will send one or more lamps on 30 days' trial to Gas Companies who maintain the lamps. Write for quotations and circulars. We will save you money.

Detroit Arc Gas Light Company,

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CHARLES MILLAR & SON CO., Selling Agents, Utica, N.Y.

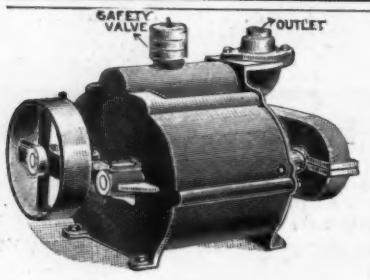
Flanged Pipe and Fittings, Hydrants, Gates, Pig Lead, Jute, etc.

UTICA PIPE FOUNDRY CO.

Manufacturers of Lead Pipe, Solder, etc., and Jobbers of Plumbers' and Tinners' Goods.

CAST IRON PIPE and SPECIALS FOR WATER AND GAS

Wholesale Eastern Agents AKRON VITRIFIED SEWER PIPE.



REVIVIFYING IN SITU.

An inexpensive device for admitting air into purifying boxes. Belted direct to exhauster shaft the speed of blower is automatically regulated. Size shown in cut, 10″ x 10½″ x 16″, has a capacity of 172 cubic inches per revolution, and can be speeded to admit any percentage of air desired. Specially designed for gas companies.

A large number of these machines are now in daily use, giving entire satisfaction.

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PARKER-RUSSELL MINING AND MFG. CO.,

PROPRIETORS OF THE

OAKHILL GAS RETORT AND FIREBRICK WORKS.

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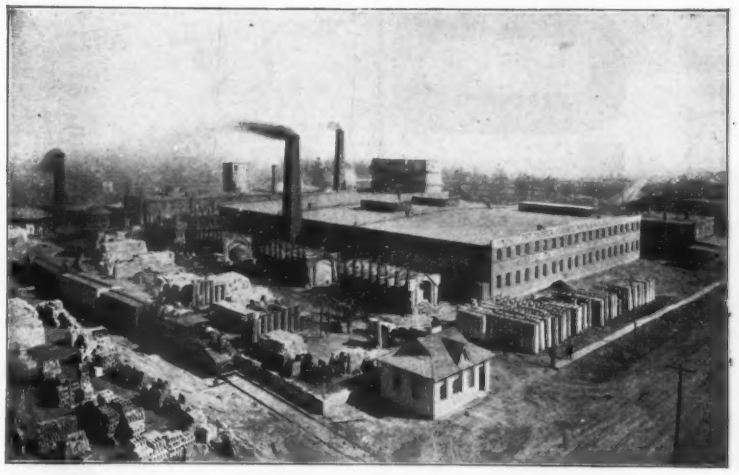

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New York Office:
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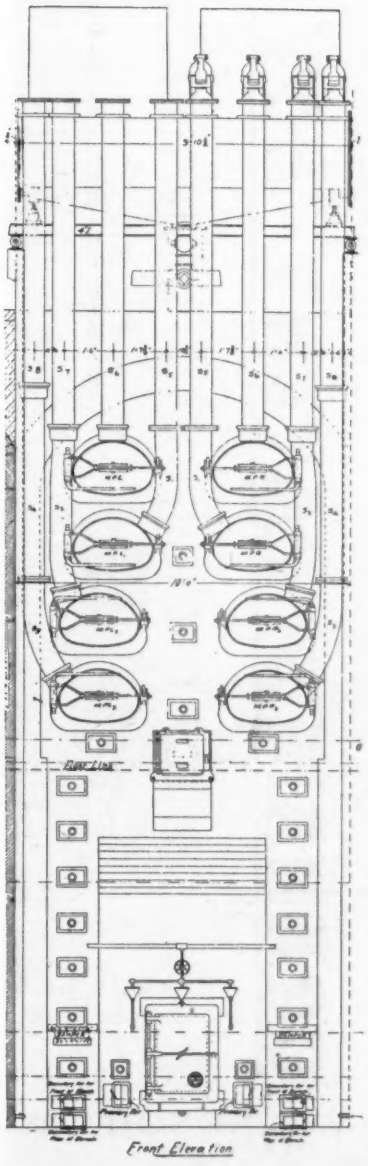
45 Broadway.



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Half and Full Depth Benches of Our Own Design,

Containing 6, 8 or 9 Retorts.

SLOPERS.--We have perfected plans of INCLINED RETORT BENCHES, designed to meet conditions prevailing in America, and constructed entirely of American materials.

We build Benches complete, ready for gas making. Also

RETORT HOUSES,

COAL AND COKE CONVEYING MACHINERY.

Plans, Specifications and Estimates cheerfully furnished.

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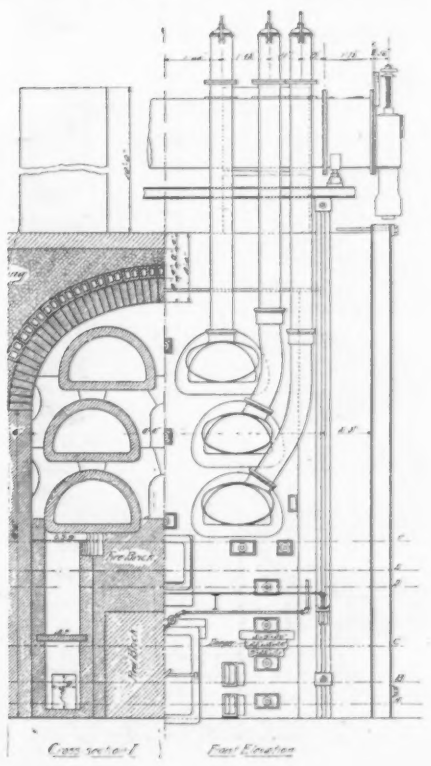


ADAM WEBER SONS.

BUILDERS AND CONSTRUCTORS OF THE

"MAURICE GRAHAM" SYSTEM OF

INCLINED RETORT

INSTALLATIONS COMPLETE.

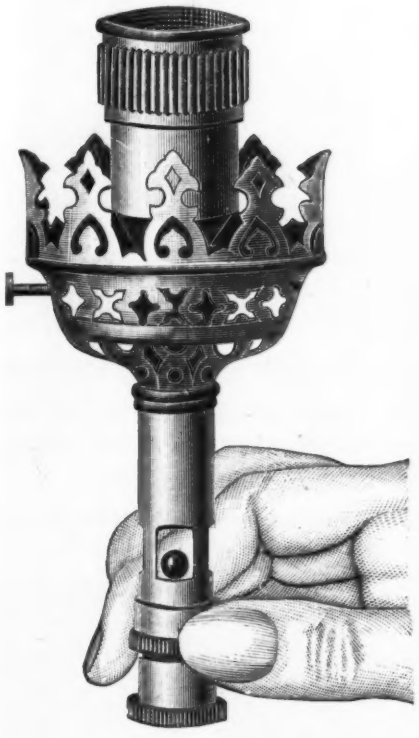
WE HAVE A STAFF OF EXPERIENCED AND TRAINED ENGINEERS TO ERECT THIS SYSTEM.

THE LARGEST INSTALLATIONS IN THE WORLD WITH 20-FOOT RETORTS AND BENCHES OF 9'S IN ACTION. NOW OPERATING AT EDINBOROUGH, LEEDS, MILAN, PARIS, LONDON, ETC.

GRAHAM'S PATENT HOT COKE CONVEYOR.

FOR QUENCHING AND DRYING THE COKE DURING TRANSIT.

See Articles in AMERICAN GAS LIGHT JOURNAL, February 9th and 16th, 1903.



The Ball Check.

Pat. Nov 25, 1902.

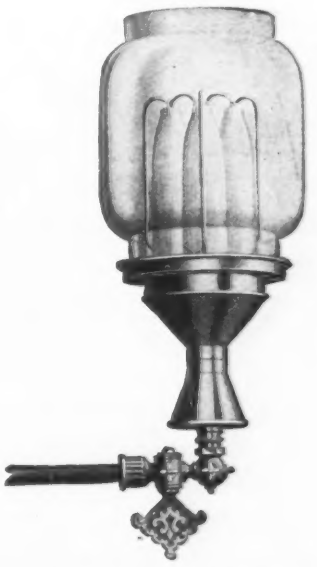
ANY BURNER.

ANY GAS--ANY PRESSURE.
INSTANT ADJUSTMENT.

HIGHEST EFFICIENCY.

"JUST A TWIST OF YOUR WRIST AND YOUR LIGHT IS BRIGHT."

"THE BALL DOES IT ALL."



Triple Arc Ball Check Lamp fits any chandelier or gas bracket. Three times the light of the single mantle burner, yet burns only double the amount of gas. More light—less gas. Greatest illuminator in the world for the money.

Send for the Ball Check Light Booklet.

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16 AND 18 PARK PLACE,
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NEW ENGLAND BALL CHECK LIGHT CO.,
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Estimates Furnished on any kind of Work in Connection with Gas or Water Plants.

SPECIAL ATTENTION GIVEN TO THE REMODELLING AND EXTENDING OF THE PROPERTIES OF WORKS NOT UP-TO-DATE.

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THE GAS MACHINERY CO.,

OFFICES: 720-722 CITIZENS BUILDING,

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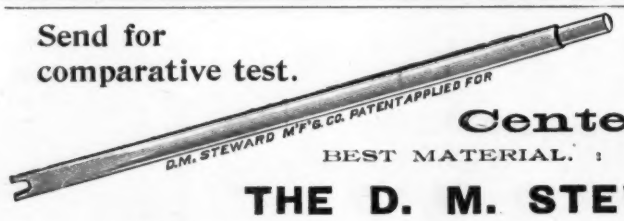
Coal and Water Gas Apparatus, Bye-Product Machinery, Structural Work and Connections.

Send for comparative test.



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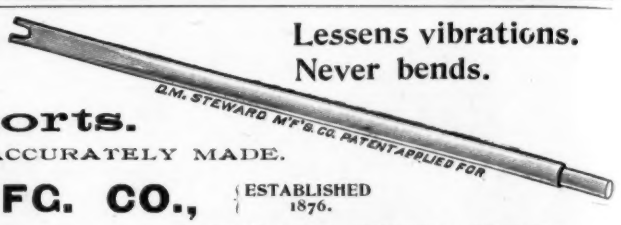
(TRADE MARK)
Center-Supports.
BEST MATERIAL. : : : : : : ACCURATELY MADE.



Lessens vibrations. Never bends.

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FACTORY AND GENERAL OFFICE: Chattanooga, Tenn. 3

Gas Analyses of All Sorts and Conditions,
—OR—
Analyses of Solid and Liquid Materials as Well,
That are needed by Gas Companies at any time in the conduct of their business, may be obtained from
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WE PURCHASE:
Gas properties,
Electric light properties.
Street railway properties.
Also desirable franchises.
W. R. FABEN CONSTRUCTION CO.,
1383-tf 317 St. Claire Street, Toledo, O.

Hughes' "GAS WORKS,"
Their Construction and Arrangement,
And the Manufacture and Distribution of Coal Gas.
Originally written by SAM'L HUGHES, C.E.
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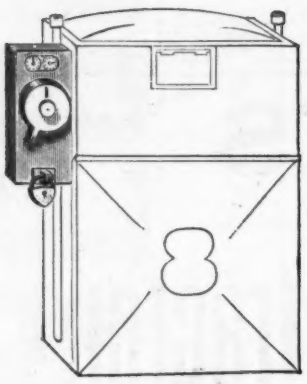
WM. RICHARDS, C.E.
Eighth Edition, Revised, with Notices of Recent Improvements.
Price, $1.65.
A. M. CALLENDER & CO., 42 PINE ST., N. Y. CITY.

AUTOMATIC
Send for Catalogue.
SCALES
RICHARDSON SCALE CO., 21 Park Row, NEW YORK CITY.

GAS BURNERS,
To burn a given amount at a stated pressure, made to order. Samples furnished. Also, small oil and air valves, slow-feed valves for high pressure, and small brasswork in general.
Drip Pumps, Service Cleaners, Gasfitters' Proving Pumps and Mercury Gauges.
C. GEFRORER & SON,
248 North 8th Street, Philadelphia, Pa.



A PERFECT PREPAYMENT ATTACHMENT.
PERFECTION is a big statement, but write for sample of the "REEVES" Prepay and see if we substantiate the claim. :: :: :: :: :: :: :: ::
Gives consumer more than 10 hours' warning before gas goes out. Ten dollars can be prepaid at one time. Can be fitted to any make of meter. Device cannot be "beaten." :: :: :: :: :: :: :: :: :: :: :: :: :: ::
REEVES MFG. CO., - - - NEW HAVEN, CONN.

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FRED. BREDEL COMPANY,
ENGINEERS AND BUILDERS OF GAS PLANTS.
Inclined Benches, own system, Recuperative Furnaces, Exhausters, Exhauster Governors, Condensers, Washers, Coolers, Wet Purifying Plants, Purifiers, Oxide Elevators, Hydraulic and Dry Coke Conveyors.
Special High Grade Material for Recuperative Furnaces.
Licensees for ARROLL-FOULIS Charging and Discharging Machines and FRONHAUSER Coke Conveyors. OFFICE, 405 KEENE ST., MILWAUKEE, WIS.

COAL TAR AND AMMONIA.
THIRD AND ENLARGED EDITION.
BY
GEORGE LUNGE, PH.D.
Price, $15. For Sale by
A. M. CALLENDER & CO., - - 42 Pine Street, New York City.

Have you seen BRAY'S

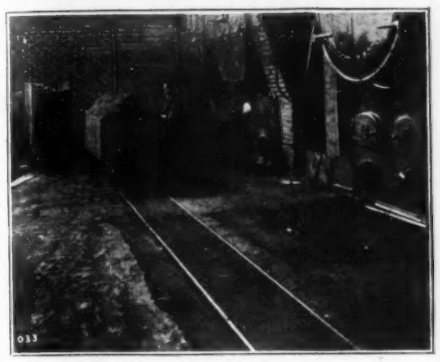
New "ELTA" Burners?

These are the only Acetylene Burners which can be turned high or low without carbonizing, and, therefore, they remove one of the greatest barriers to the progress of lighting by Acetylene. Write for further information.

WILLIAM M. CRANE COMPANY,

SOLE AGENTS FOR THE UNITED STATES,

1131 Broadway, New York.



Stanley Rule and Level Company, New Britain, Conn.

A Convenient Way

To carry coal to a boiler room is to install an "Industrial" Railway and charging car. It *is not* a costly item.

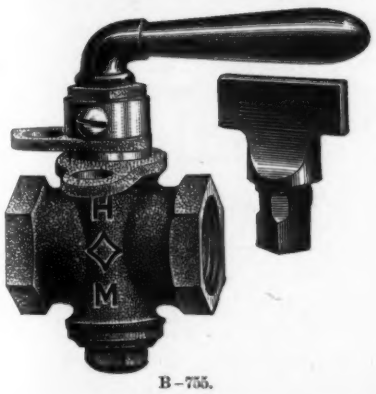
A WHEELBARROW WITH A CARRYING CAPACITY OF 250 POUNDS WOULD HAVE TO MAKE EIGHT TRIPS TO HANDLE THE AMOUNT OF COAL WHICH A CHARGING CAR CARRIES AT ONE TIME, NAMELY, 2,000 POUNDS, AND LESS EFFORT IS REQUIRED TO MOVE THE CAR WITH ITS TON LOAD THAN THE WHEELBARROW WITH ITS 250-POUND LOAD.

Write for Catalogue 0227.

C. W. HUNT COMPANY,
WEST NEW BRIGHTON, N. Y.

NEW YORK, 45 BROADWAY.

Mueller Gas Cocks.



B-755.

TOO little is not as much as you pay for, and too much is more paid for than you need.

In **Mueller Gas Cocks** you find a happy medium--not so little metal as to leave them weak, nor yet so much as to make them costly.

Made in 145 styles, seven sizes in each style.

MADE ONLY BY

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DECATUR, ILLS., U. S. A.

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Globe
Street and Boulevard
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Cheapest and Best.

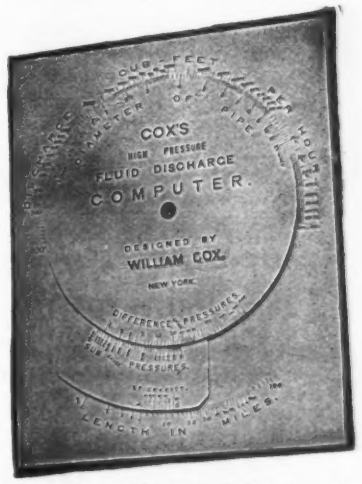
THOUSANDS IN USE WITH INCANDESCENT BURNERS.

Send for Catalogues.

THOMAS T. W. MINER,

821-823 Eagle Av., N.Y.

Cox's High Pressure Fluid Discharge Computer.



This Computer solves the following formula, which is applicable to Gas, Air and other elastic fluids, flowing through long pipes with high initial pressures:

Discharge in cubic feet per hour at atmospheric pressure $= 33.3 \sqrt{\frac{d^5 \times (p_1^2 - p_2^2)}{L \times w}}$

Where

d = diameter of pipe in inches,
p_1 = absolute initial pressure in pounds per square inch,
p_2 = absolute terminal pressure in pounds per square inch,
L = length of pipe in miles,
w = specific gravity of the fluid when air = 1.

To Find the Discharge from a Pipe and the Required Size of Pipe.

(1.) Set the specific gravity of the fluid opposite the length of pipe;

(2.) Bring the DIFFERENCE of the initial and terminal gauge pressures opposite the SUM of the initial and terminal gauge pressures;

(3.) Opposite any diameter of pipe will now be found the discharge in cubic feet per hour at atmospheric pressure; and

(4.) Opposite any desired discharge will also be found the required diameter of pipe.

Price of the Computers, in Cloth Case, 6½ x 8 inches, $5 Each, Net.

For Sale by

A. M. CALLENDER & CO., 42 Pine Street, New York City.

THE

Ludlow Valve Mfg. Co.,

TROY, N. Y., U. S. A.

Double and Single Gate Valves, ¼" to 72",

—FOR—

Gas, Water, Steam, Oil, Ammonia, Etc.

HOT GAS VALVES A SPECIALTY.

Send for Catalogue.

LLOYD CONSTRUCTION COMPANY,

DETROIT, MICH.

LOWE DOUBLE SUPERHEATER WATER GAS APPARATUS.

Coal Gas Condensing and Scrubbing Apparatus.
Purifiers with Plain or Reversing Center Valves.
The Lloyd System of Valve Connections.
PLAIN OR REVERSING (PATENT APPLIED FOR).
Oxide, Coal and Coke Elevators and Machinery.
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BY UTILIZING A

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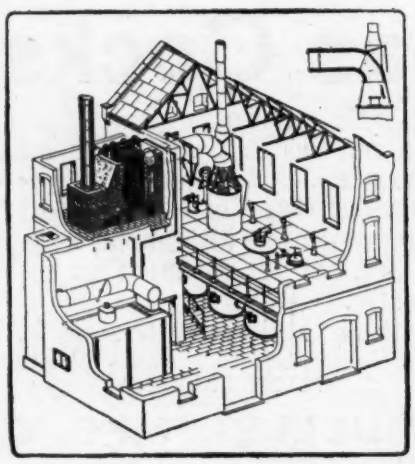

To absorb the heat now going to waste when you blow through your superheater to heat the feed water for your boilers to the temperature of the steam. This is now being done at the Poughkeepsie Gas Works, Poughkeepsie, N. Y. : : : : :

Write for full particulars how this is accomplished, the saving effected, and the advantages gained, to the

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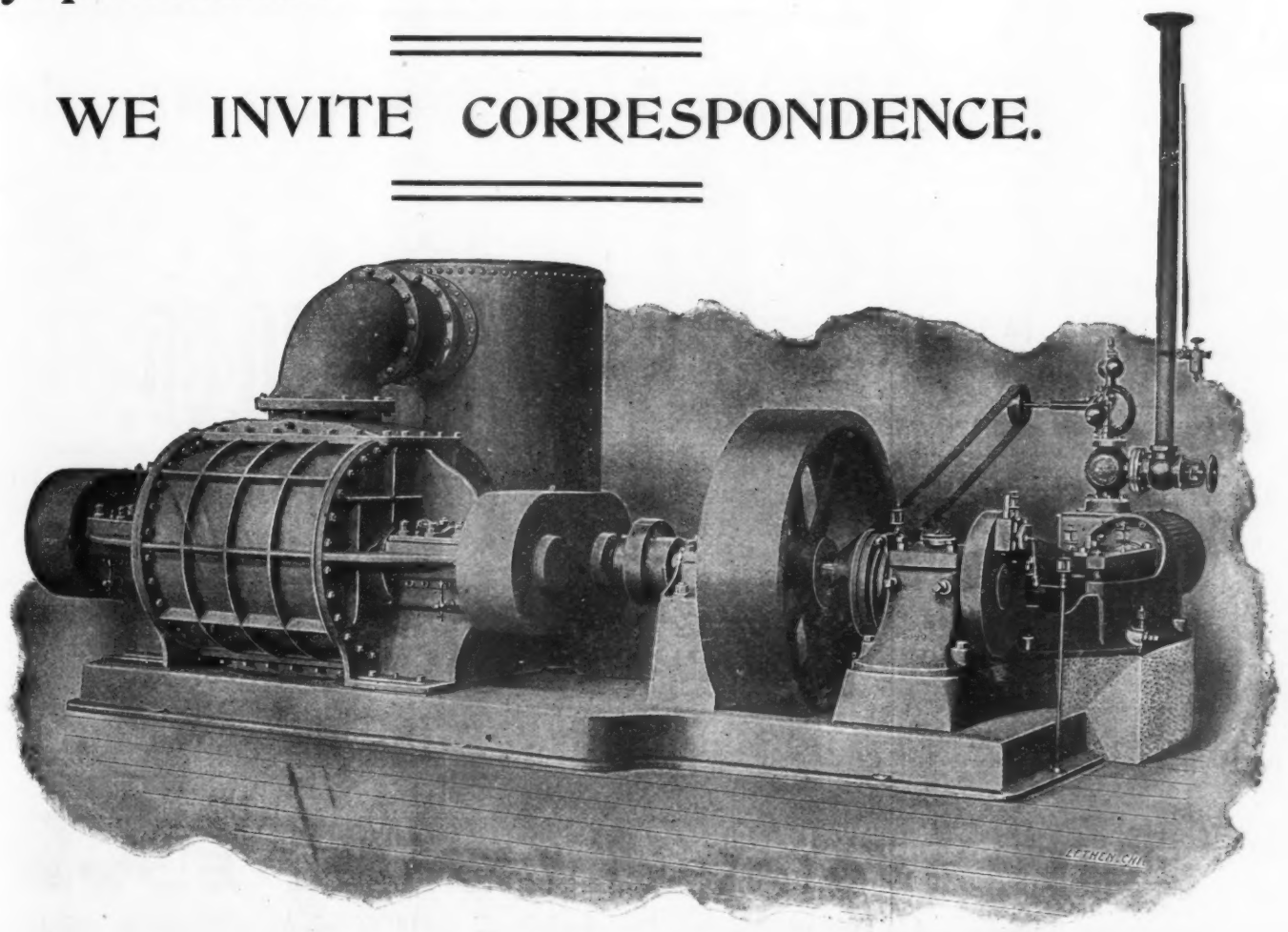

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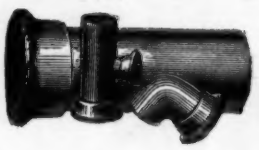

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FOR IMPROVING BAD DRAUGHT IN BOILERS, AND FOR BURNING BREEZE OR OTHER WASTE MATERIAL.

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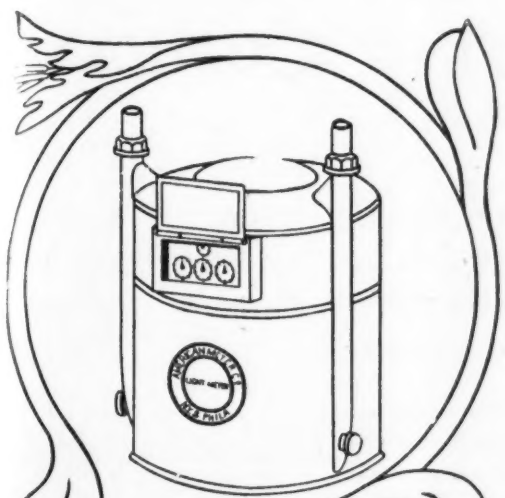
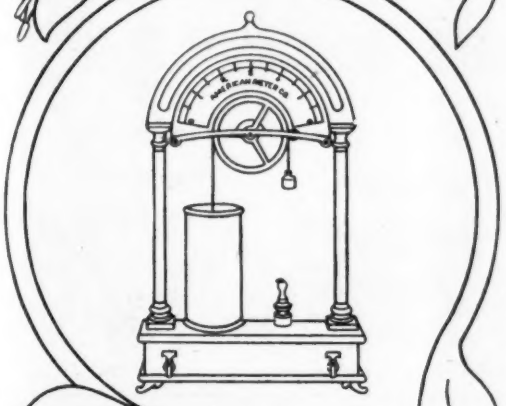
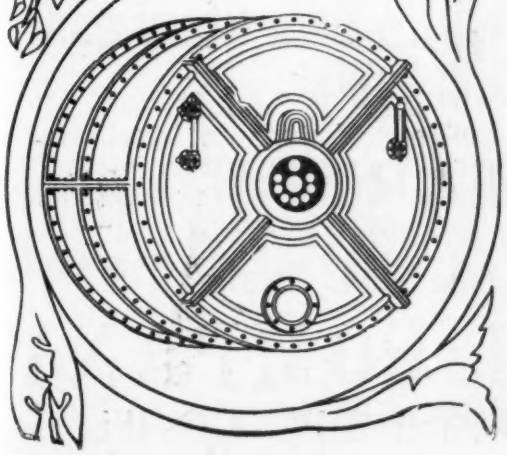






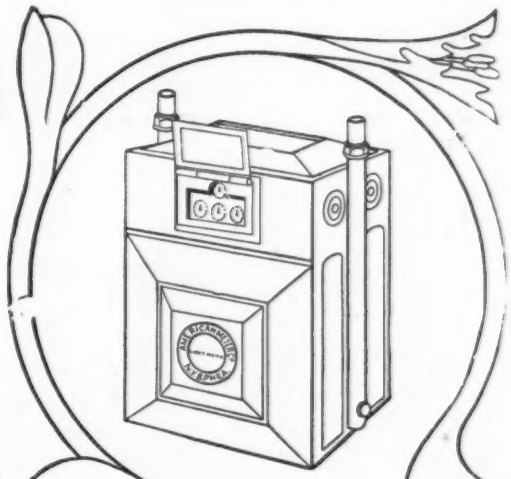
PUBLIC LIGHTING TABLE.

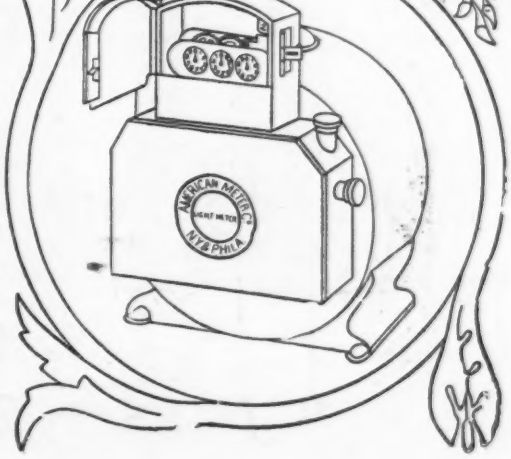
APRIL, 1903.

Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Wed.	1	6.50 PM	4.50 AM	6.10	4.55
Thu.	2	10.30	4.50	6.15	4.40
Fri.	3	11.30	4.50	6.15	4.40
Sat.	4	12.20 AM FQ	4.50	6.15	4.40
Sun.	5	1.10	4.40	6.15	4.40
Mon.	6	1.50	4.40	6.15	4.40
Tue.	7	2.30	4.40	6.15	4.40
Wed.	8	3.10	4.40	6.15	4.40
Thu.	9	3.40	4.40	6.25	4.30
Fri.	10	No L.	No L.	6.25	4 30
Sat.	11	No L. FM	No L.	6.25	4.30
Sun.	12	No L.	No L.	6.25	4.30
Mon.	13	7.10 PM	9.30 PM	6.25	4.30
Tue.	14	7 10	10.30	6.25	4.30
Wed.	15	7.10	11.20	6.25	4.30
Thu.	16	7.10	12.10 AM	6.30	4.20
Fri.	17	7.10	1.00	6.30	4.20
Sat.	18	7.10	1.40	6.30	4 20
Sun.	19	7.10 LQ	2.20	6.30	4.20
Mon.	20	7.10	2.50	6.30	4.20
Tue.	21	7.10	3.20	6.30	4.20
Wed.	22	7.10	4.00	6.30	4.20
Thu.	23	7.10	4.10	6.40	4.10
Fri.	24	7.10	4.10	6.40	4.10
Sat.	25	7.10	4.10	6.40	4.10
Sun.	26	7.20	4.10	6,40	4.10
Mon.	27	7.20 NM	4.10	6,40	4.10
Tue.	28	7.20	4.10	6.40	4.10
Wed.	29	7.20	4.10	6.40	4.10
Thu.	30	7.20	4.10	6.45	4.00

TOTAL HOURS LIGHTING DURING 1903.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	245.00	January	423.20
February	192.00	February	355.25
March	201.00	March	355.35
April	167.20	April	298.50
May	152.00	May	264.50
June	131.00	June	234.25
July	140.40	July	243.45
August	156.20	August	280.25
September	171.20	September	321.15
October	198.20	October	374.30
November	216.30	November	401.40
December	232.10	December	433.45
Total, yr.	2203.40	Total, yr.	3987.45





NEW YORK, 33 Nassau Street. PHILADELPHIA, Broad and Arch Streets. CHICAGO, Foot of Orleans Street. BOSTON, 624 Tremont Building.
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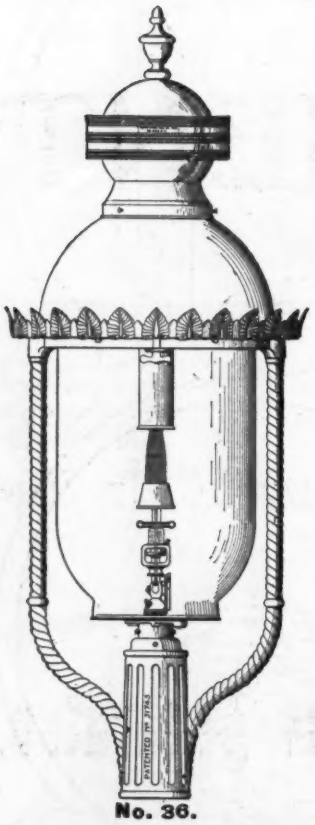
.... OF AMERICA ....



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By means of the Welsbach System of street lighting the superiority of GAS over electricity for street lighting has been fully demonstrated.

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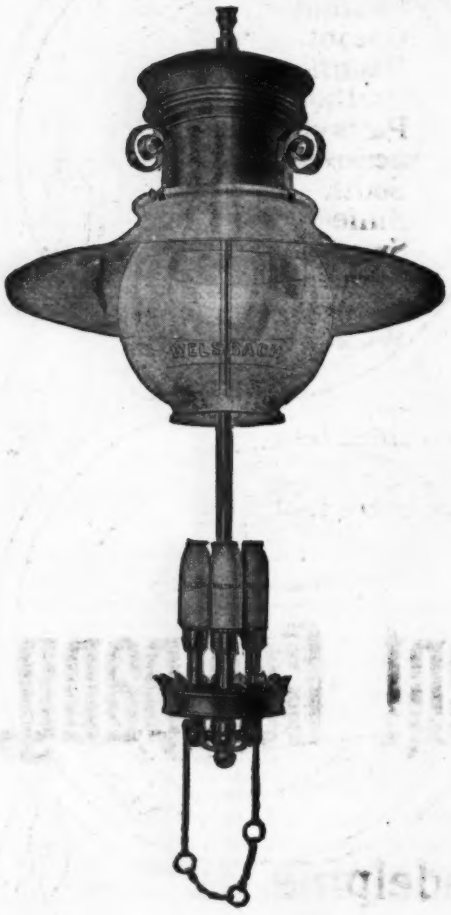
No. 38.

The Welsbach Gas Arc for Indoor Lighting.



The cut tells the story—but not all of it. Get one lamp and light it—then the tale's told from beginning to end. For one Welsbach Gas Arc Lamp is a better salesman than 20 pages of advertising.

Here's what it would show if you give it a chance to prove its worth:

1. A mechanical construction and finish that insures the greatest durability.
2. The renewal of mantles and the cleaning of globes without removal of globe.
3. The greatest amount of candle power with least consumption of gas.
4. A by-pass cock so constructed as to permit all or only one mantle burning at a time.
5. A pilot light that consumes but 1 foot of gas in 24 hours. Costs $\frac{1}{10}$ of a cent a day.

Give it a Chance to Tell its Own Story and it Won't Disappoint.

Let us send you one lamp—doesn't cost a fortune—and it will answer every question you put to it; make good on every test given it. You know the only proof of the pudding? What's the use in a fellow telling you it tastes good? Taste it yourself, then you know.

May we Send you ONE Lamp?

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Brooklyn, N. Y.	Lakewood, N. J.	Portland, Me.
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Evanston, Ills.	New Orleans, La.	Washington, N. C.
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TOTAL DAILY CAPACITY, 1902, . . 32,825,000 cubic feet.
TOTAL SETS TO DATE, ... 447
TOTAL DAILY CAPACITY, ... 299,670,000 cubic feet.

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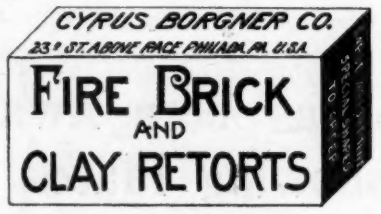

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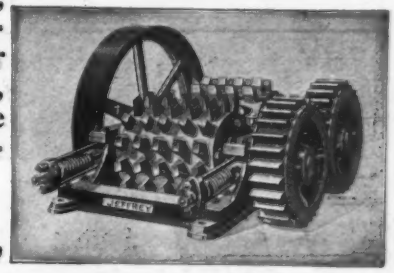

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Strong, Simple, Durable. Will Crush any Size Desired.

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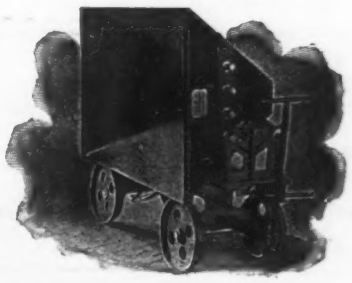

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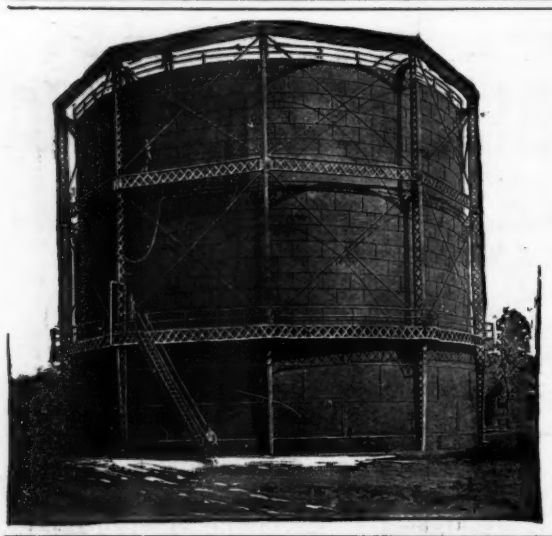

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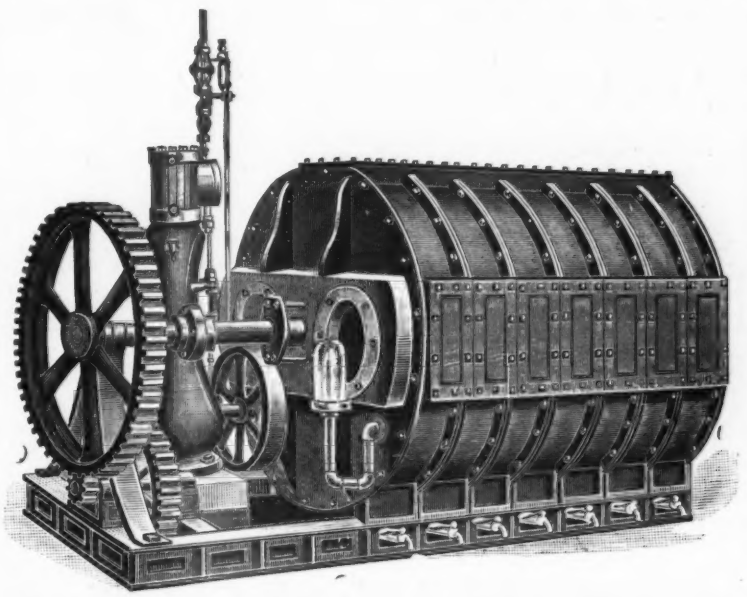

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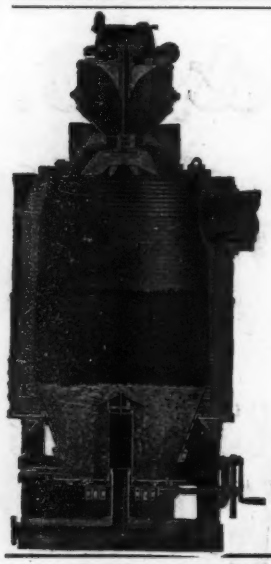

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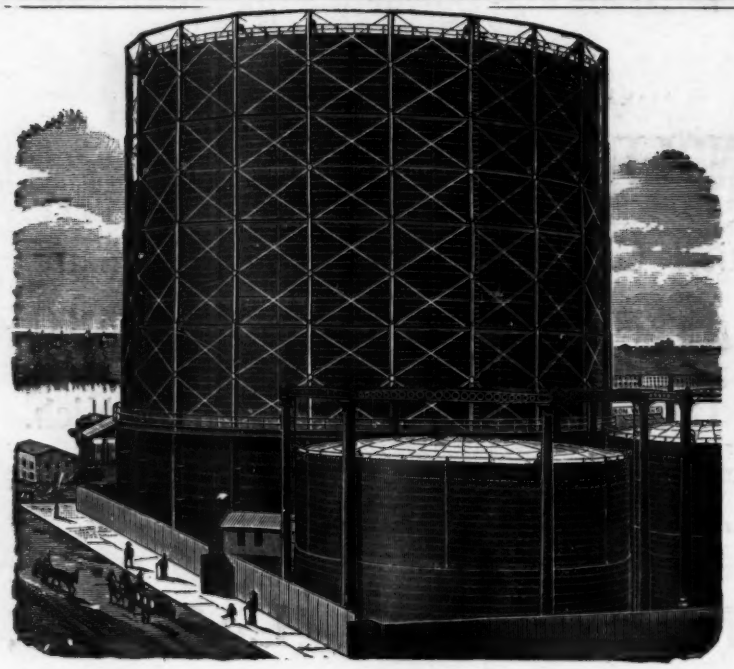

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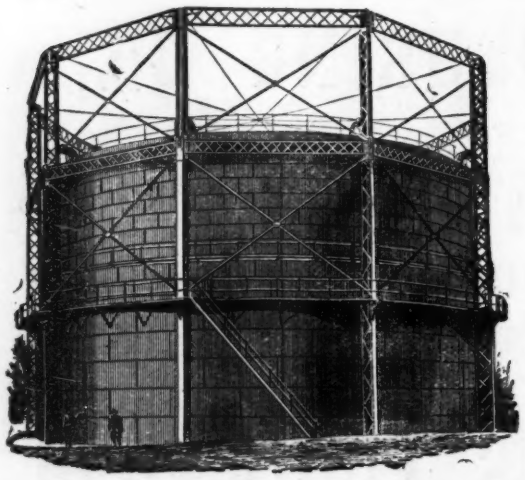

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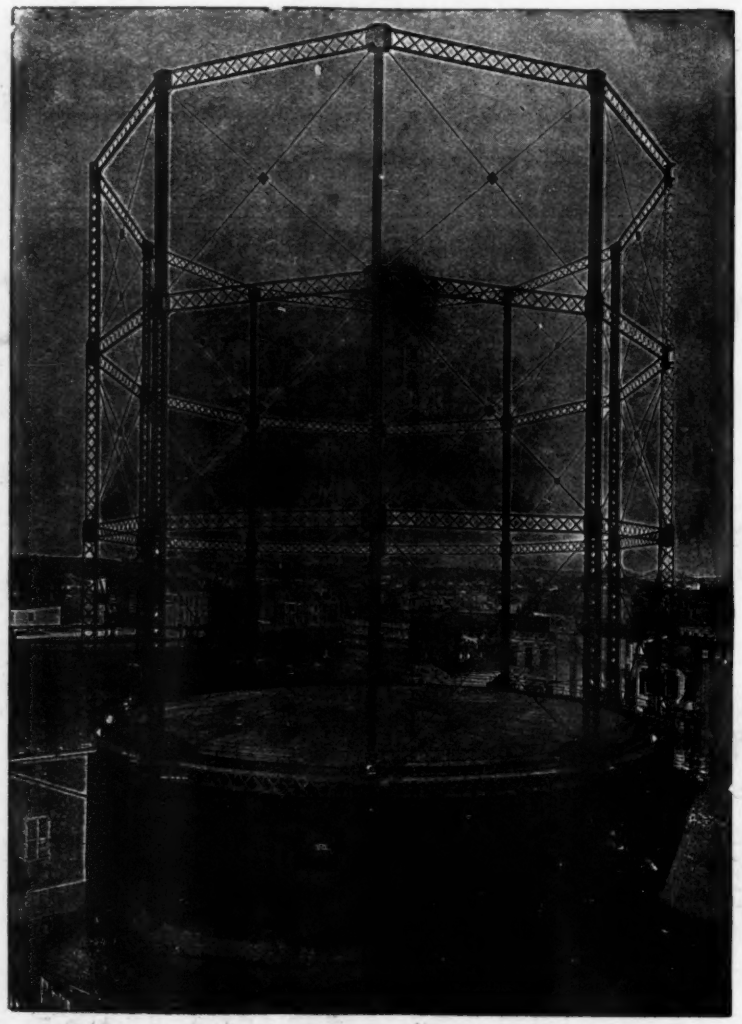

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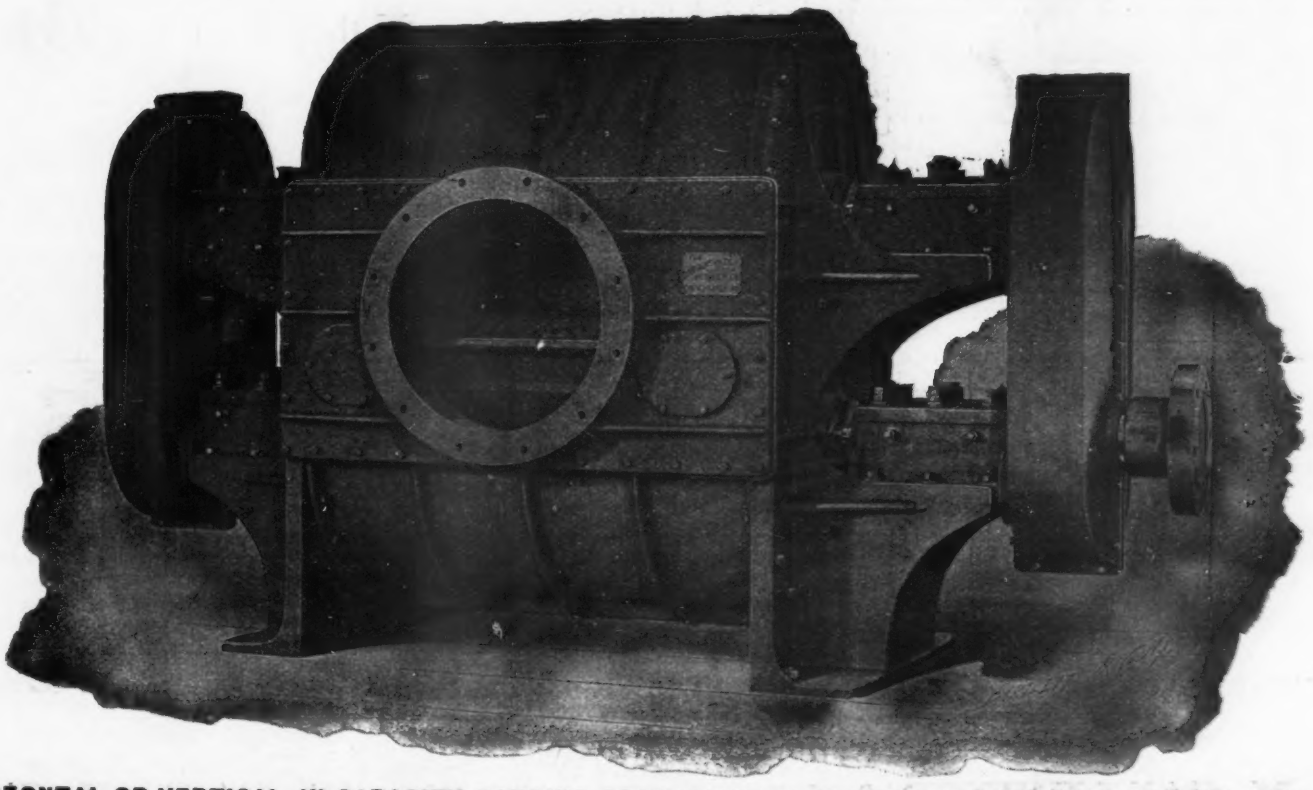

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